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THE SINS OF LEGISLATORS.

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II.

THE reply to all this will doubtless be that nothing better than guidance by "collective wisdom" can be had—that the select men of the nation, led by a reselected few, bring their best powers, enlightened by all the knowledge of the time, to bear on the matters before them. "What more would you have?" will be the question asked by most.

My answer is that this best knowledge of the time with which legislators are said to come prepared for their duties is a knowledge of which the greater part is obviously irrelevant, and that they are blameworthy for not seeing what is the relevant knowledge. No amount of the linguistic acquirements by which many of them are distinguished will help their judgments in the least; nor will they be appreciably helped by the literatures these acquirements open to them. Neither the history of Thucydides, nor the biographies of Plutarch, nor the dialogues of Plato, will in any considerable degree prepare them for judging how this or that measure will operate on social life. Not even Aristotle's "Politics" will give them much help in judging how acts of Parliament are likely to work. They may ponder on the doings of all the great men by whom, according to the Carlylean theory, society is framed, and they may spend years over those accounts of international conflicts, and treacheries, and intrigues, and treaties, which fill historical works, without being much nearer understanding the how and the why of social structures and actions, and the ways in which laws affect them. Nor does such information as is picked up in the

factory, on 'change, or in the justice-room, go far toward the required preparation.

That which is really needed is a systematic study of natural causation as displayed among human beings socially aggregated. Though a distinct consciousness of causation is the last trait which intellectual progress brings—though with the savage a simple mechanical cause is not conceived as such—though even among the Greeks the flight of a spear was thought of as guided by a god—though, from their times down almost to our own, epidemics have been habitually regarded as of supernatural origin—and though among social phenomena, the most complex of all, causal relations may be expected to continue longest unrecognized; yet, in our days, the existence of such causal relations has become clear enough to force on all who think the inference that before meddling with them they should be diligently studied. The mere facts, now familiar, that there is a connection between the numbers of births, deaths, and marriages, and the price of corn, and that in the same society during the same generation the ratio of crime to population maintains a kindred regularity, should be sufficient to make all see that human desires, using as guide such intellect as is joined with them, act with approximate uniformity. It should be inferred that, among social causes, those initiated by legislation, similarly operating with an average regularity, must not only change men's actions, but, by consequence, change their natures—probably in ways not intended. There should be a recognition of the fact that social causation, more than all other causation, is a fructifying causation; and it should be seen that indirect and remote effects are no less inevitable than proximate effects. I do not mean that there is denial of these statements and inferences. But there are beliefs and beliefs—some which are held but nominally, some which influence conduct in small degrees, some which sway it irresistibly under all circumstances; and unhappily the beliefs of law-makers respecting causation in social affairs are of the superficial sort. Let us look at some of the truths which they tacitly admit, but which are scarcely at all taken account of in legislation.

There is the indisputable fact that each human being is in a certain degree modifiable both physically and mentally. Every theory of education, every discipline, from that of the arithmetician to that of the prize-fighter, every proposed reward for virtue or punishment for vice, implies the belief, embodied in sundry proverbs, that the use or disuse of each faculty, bodily or mental, is followed by an adaptive change in it—loss of power or gain of power according to demand.

There is the fact, also in its broader manifestations universally recognized, that modifications of nature, in one way or other produced, are inheritable. No one denies that by the accumulation of small changes, generation after generation, constitution fits itself to condi-

tions; so that a climate is wholesome to the adapted race which is fatal to other races. No one denies that peoples who belong to the same original stock but have spread into different habitats where they have led different lives have acquired in course of time different aptitudes and different tendencies. No one denies that under new conditions new national characters are even now being molded, as witness the Americans. And if no one denies a process of adaptation everywhere and always going on, it is a manifest implication that adaptive modifications must be set up by every change of social conditions.

To which there comes the undeniable corollary that every law which serves to alter men's modes of action—compelling, or restraining, or aiding, in new ways—so affects them as to cause in course of time an adjusted nature. Beyond any immediate effect wrought, there is the remote effect, wholly ignored by most—a remolding of the average character: a remolding which may be of a desirable or an undesirable kind, but which in any case is the most important of the results to be considered.

Other general truths, which the citizen, and still more the legislator, ought to contemplate until they become wrought into his intellectual fabric, are disclosed when we ask how social activities are produced; and when we recognize the obvious answer that they are the aggregate results of the desires of individuals who are severally seeking satisfactions, and ordinarily pursuing the ways which, with their pre-existing habits and thoughts, seem the easiest—following the lines of least resistance: the truths of political economy being so many sequences. It needs no proving that social structures and social actions must in some way or other be the outcome of human emotions guided by ideas—either those of ancestors or those of living men. And that the right interpretation of social phenomena is to be found in the co-operation of these factors from generation to generation follows inevitably.

Such an interpretation soon brings us to the inference that, of the aggregate results of men's desires seeking their gratifications, those which have prompted their private activities and their spontaneous co-operations have done much more toward social development than those which have operated through governmental agencies. That abundant crops now grow where once only wild berries could be gathered is due to the pursuit of individual satisfactions through many centuries. The progress from wigwams to good houses has resulted from wishes to increase personal welfare; and towns have arisen under the like promptings. Beginning with peddlers and with traffic at meetings on occasions of religious festivals, the trading organization, now so extensive and complex, has been produced entirely by men's efforts to achieve their private ends. Perpetually governments have thwarted and deranged the growth, but have in no

way furthered it, save by partially discharging their proper function and maintaining social order. So, too, with those advances of knowledge and those improvements of appliances by which these structural changes and these increasing activities have been made possible. It is not to the state that we owe the multitudinous useful inventions from the plow to the telephone; it is not the state which made possible extended navigation by a developed astronomy; it is not the state which made the discoveries in physics, chemistry, and the rest, which guide modern manufacturers; it is not the state which devised the machinery for producing fabrics of every kind, for transferring men and things from place to place, and for ministering in a thousand ways to our comforts. The world-wide transactions going on in merchants' offices, the rush of traffic filling our streets, the retail distributing system which brings everything within easy reach and delivers the necessaries of life daily at our doors, are not of governmental origin. All these are the results of the spontaneous activities of citizens, separate or combined. Nay, to these spontaneous activities governments owe the very means of performing their duties. Divest the political machinery of all those aids which science and art have yielded it—leave it with those only which state-officials have invented—and its functions would cease. The very language in which its laws are registered and the orders of its agents daily given is an instrument not in the remotest degree due to the legislator, but is one which has unawares grown up during men's intercourse while pursuing their personal satisfactions.

And then a truth, to which the foregoing one introduces us, is that this spontaneously-formed social organization is so bound together that you can not act on one part without acting more or less on all parts. We see this unmistakably when a cotton-famine, first paralyzing certain manufacturing districts and then affecting the doings of wholesale and retail distributors throughout the kingdom, as well as the people they supply, goes on to affect the makers and distributors, as well as the wearers, of other fabrics—woolen, linen, etc. Or we see it when a rise in the price of coal, besides influencing domestic life everywhere, hinders the greater part of our industries, raises the prices of the commodities produced, alters the consumption of them, and changes the habits of consumers. What we see clearly in these marked cases happens in every case in sensible or in insensible ways. And, manifestly, acts of Parliament are among those factors which, beyond the effects directly produced, have countless other effects of multitudinous kinds. As I heard remarked by a distinguished professor, whose studies give ample means of judging, "When once you begin to interfere with the order of Nature there is no knowing where the results will end." And, if this is true of that sub-human order of Nature to which he referred, still more is it true of that order of Nature existing in the social arrangements produced by aggregated human beings.

And now, to carry home the conclusion that the legislator should bring to his business a vivid consciousness of these and other such broad truths concerning the human society with which he proposes to deal, let me present somewhat more fully one of them not yet mentioned.

The continued life of every higher species of creature depends on conformity, now to one, now to the other, of two radically-opposed principles. The early lives of its members and the adult lives of its members have to be dealt with in contrary ways. We will contemplate them in their natural order.

One of the most familiar facts is that animals of superior types, comparatively slow in reaching maturity, are enabled, when they have reached it, to give more aid to their offspring than animals of inferior types. The adults foster their young during periods more or less prolonged, while yet the young are unable to provide for themselves; and it is obvious that maintenance of the species can be secured only by a parental care adjusted to the need consequent on imperfection. It requires no proving that the blind, unfledged hedge-bird, or the young puppy even after it has acquired sight, would forthwith die if it had to keep itself warm and obtain its own food. The gratuitous parental aid must be great in proportion as the young one is of little worth, either to itself or to others; and it may diminish as fast as, by increasing development, the young one acquires worth, at first for self-sustentation, and by-and-by for sustentation of others. That is to say, during immaturity, benefits received must be inversely as the power or ability of the receiver. Clearly, if during this first part of life benefits were proportioned to merits, or rewards to deserts, the species would disappear in a generation.

From this *régime* of the family-group, let us turn to the *régime* of that larger group formed by the adult members of the species. Ask what happens when the new individual, acquiring complete use of its powers and ceasing to have parental aid, is left to itself. Now there comes into play a principle just the reverse of that above described. Throughout the rest of its life, each adult gets benefit in proportion to merit—reward in proportion to desert: merit and desert in each case being understood as ability to fulfill all the requirements of life—to get food, to secure shelter, to escape enemies. Placed in competition with members of its own species, and in antagonism with members of other species, it dwindles and gets killed off, or thrives and propagates, according as it is ill-endowed or well-endowed. Manifestly an opposite *régime*, could it be maintained, would, in course of time, be fatal to the species. If the benefits received by each member of it were proportionate to its inferiority—if, as a consequence, multiplication of the inferior was furthered and multiplication of the superior hindered, progressive degradation would result; and eventually

the species, as a whole, would fail to hold its ground in presence of antagonistic species and competing species.

The broad fact, then, here to be noted, is that Nature's modes of treatment inside the family-group and outside the family-group are diametrically opposed to one another; and that the intrusion of either mode into the sphere of the other would be fatal to the species, either immediately or remotely.

Does any one think that the like does not hold of the human species? He can not deny that within the human family, as within any inferior family, it would be fatal to proportion benefit to merit. Can he assert that outside the family, among adults, there should not be proportioning of benefit to merit? Will he contend that no mischief will result if the lowly endowed are enabled to thrive and multiply as much as, or more than, the highly endowed? A society of men, standing toward other societies in relations of either antagonism or competition, may be considered as a species, or, more literally, as a variety of a species; and it must be true of it as of other species or varieties, that it will be unable to hold its own in the struggle with other societies, if it disadvantages its superior units that it may advantage its inferior units. Surely none can fail to see that were the principle of family life to be adopted and fully carried out in social life—were reward always great in proportion as desert was small—fatal results to the society would quickly follow; and, if so, then even a partial intrusion of the family *régime* into the *régime* of the state will be slowly followed by fatal results. Society in its corporate capacity can not, without immediate or remote disaster, interfere with the play of these opposed principles under which every species has reached such fitness for its mode of life as it possesses, and under which it maintains that fitness.

I say advisedly—society in its corporate capacity: not intending to exclude or condemn aid given to the inferior by the superior in their individual capacities. Though, when given so indiscriminately as to enable the inferior to multiply, such aid entails mischief; yet in the absence of aid given by society, individual aid, more generally demanded than now, and associated with a greater sense of responsibility, would, on the average, be given with the effect of fostering the unfortunate worthy rather than the innately unworthy: there being always, too, the concomitant social benefit arising from culture of the sympathies. But all this may be admitted while asserting that the radical distinction between family-ethics and state-ethics must be maintained; and that, while generosity must be the essential principle of the one, justice must be the essential principle of the other—a rigorous maintenance of those normal relations among citizens under which each gets in return for his labor, skilled or unskilled, bodily or mental, as much as is proved to be its value by the demand for it: such return, therefore, as will enable him to thrive and rear offspring in pro-

portion to the superiorities which make him valuable to himself and others.

And yet, notwithstanding the conspicuousness of these truths, which should strike every one who leaves his lexicons, and his lawdeeds, and his ledgers, and looks abroad into that natural order of things under which we exist, and to which we must conform, there is continual advocacy of paternal government. The intrusion of family-ethics into the ethics of the state, instead of being regarded as socially injurious, is more and more demanded as the only efficient means to social benefit. So far has this delusion now gone, that it vitiates the beliefs of those who might, more than all others, be thought safe from it. In the essay to which the Cobden Club awarded its prize in 1880, there occurs the assertion that "the truth of free trade is clouded over by the *laissez-faire* fallacy"; and we are told that "we need a great deal more of paternal government—that bugbear of the old economists."*

Vitally important as is the truth above insisted upon, since acceptance or rejection of it affects the entire fabric of political conclusions formed, I may be excused if I re-emphasize it by here quoting certain passages contained in a work I published in 1850: premising only that the reader must not hold me committed to such teleological implications as they contain. After describing "that state of universal warfare maintained throughout the lower creation," and showing that an average of benefit results from it, I have continued thus:

> Note, further, that their carnivorous enemies not only remove from herbivorous herds individuals past their prime, but also weed out the sickly, the malformed, and the least fleet or powerful. By the aid of which purifying process, as well as by the fighting, so universal in the pairing-season, all vitiation of race through the multiplication of its inferior samples is prevented, and the maintenance of a constitution completely adapted to surrounding conditions, and therefore most productive of happiness, is insured.
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> The development of the higher creation is a progress toward a form of being capable of happiness undiminished by these drawbacks. It is in the human race that the consummation is to be accomplished. Civilization is the last stage of its accomplishment. And the ideal man is the man in whom all the conditions of that accomplishment are fulfilled. Meanwhile, the well-being of existing humanity and the unfolding of it into this ultimate perfection are both secured by that same beneficent though severe discipline to which the animate creation at large is subject—a discipline which is pitiless in the working out of good, a felicity-pursuing law which never swerves for the avoidance of partial and temporary suffering. The poverty of the incapable, the distresses that come upon the imprudent, the starvation of the idle, and those shoulderings aside of the weak by the strong, which leave so many "in shallows and in miseries," are the decrees of a large, far-seeing benevolence. . . .
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> To become fit for the social state, man has not only to lose his savageness, but he has to acquire the capacities needful for civilized life. Power of appli-

* "On the Value of Political Economy to Mankind," by A. N. Cumming, pp. 47, 48.

cation must be developed; such modification of the intellect as shall qualify it for its new tasks must take place; and, above all, there must be gained the ability to sacrifice a small immediate gratification for a future great one. The state of transition will, of course, be an unhappy state. Misery inevitably results from incongruity between constitutions and conditions. All these evils which afflict us, and seem to the uninitiated the obvious consequences of this or that removable cause, are unavoidable attendants on the adaptation now in progress. Humanity is being pressed against the inexorable necessities of its new position—is being molded into harmony with them, and has to bear the resulting unhappiness as best it can. The process *must* be undergone, and the sufferings *must* be endured. No power on earth, no cunningly-devised laws of statesmen, no world-rectifying schemes of the humane, no communist panaceas, no reforms that men ever did broach or ever will broach, can diminish them one jot. Intensified they may be, and are; and, in preventing their intensification, the philanthropic will find ample scope for exertion. But there is bound up with the change a *normal* amount of suffering, which can not be lessened without altering the very laws of life. . . .

Of course, in so far as the severity of this process is mitigated by the spontaneous sympathy of men for each other, it is proper that it should be mitigated; albeit there is unquestionable harm done when sympathy is shown, without any regard to ultimate results. But the drawbacks hence arising are nothing like commensurate with the benefits otherwise conferred. Only when this sympathy prompts to a breach of equity—only when it originates an interference forbidden by the law of equal freedom—only when, by so doing, it suspends in some particular department of life the relationship between constitution and conditions, does it work pure evil. Then, however, it defeats its own end. Instead of diminishing suffering, it eventually increases it. It favors the multiplication of those worst fitted for existence, and, by consequence, hinders the multiplication of those best fitted for existence—leaving, as it does, less room for them. It tends to fill the world with those to whom life will bring most pain, and tends to keep out of it those to whom life will bring most pleasure. It inflicts positive misery, and prevents positive happiness.—"Social Statics," pp. 322–325 and pp. 380, 381 (edition of 1851).

The lapse of a third of a century since these passages were published has brought me no reason for retreating from the position taken up in them. Contrariwise, it has brought a vast amount of evidence strengthening that position. The beneficial results of the survival of the fittest prove to be immeasurably greater than those above indicated. The process of "natural selection," as Mr. Darwin called it, co-operating with a tendency to variations and to inheritance of variations, he has shown to be a chief cause (though not, I believe, the sole cause) of that evolution through which all living things, beginning with the lowest and diverging and rediverging as they evolved, have reached their present degrees of organization and adaptation to their modes of life. So familiar has this truth become that some apology seems needed for naming it. And yet, strange to say, now that this truth is recognized by most cultivated people—now that the beneficent working of the survival of the fittest has been so impressed on them that, much more than people in past times, they might be expected to

hesitate before neutralizing its action—now more than ever before in the history of the world are they doing all they can to further survival of the unfittest!

But the postulate that men are rational beings continually leads one to draw inferences which prove to be extremely wide of the mark.*

"Yes, truly; your principle is derived from the lives of brutes, and is a brutal principle. You will not persuade me that men are to be under the discipline which animals are under. I care nothing for your natural-history arguments. My conscience shows me that the feeble and the suffering must be helped; and, if selfish people won't help them, they must be forced by law to help them. Don't tell me that the milk of human kindness is to be reserved for the relations between individuals, and that governments must be the administrators of nothing but hard justice. Every man with sympathy in him must feel that hunger and pain and squalor must be prevented, and that, if private agencies do not suffice, then public agencies must be established."

Such is the kind of response which I expect to be made by nine out of ten. In some of them it will doubtless result from a fellow-feeling so acute that they can not contemplate human misery without an impatience which excludes all thought of remote results. Concerning the susceptibilities of the rest, we may, however, be somewhat skeptical. Persons, who, now in this case and now in that, are angry if, to maintain our supposed national "interests" or national "*prestige*," those in authority do not promptly send out some thousands of men to be partially destroyed while destroying other thousands of men whose intentions we suspect, or whose institutions we think dangerous to us, or whose territory our colonists want, can not after all be so tender in feeling that contemplating the hardships of the poor is intolerable to them. Little admiration need be felt for the professed sympathies of men who urge on a policy which breaks up progressing societies, and who then look on with cynical indifference at the weltering confusion left behind, with all its entailed suffering and death. Those who, when a people asserting their independence successfully

* The saying of Emerson, that most people can understand a principle only when its light falls on a fact, induces me here to cite a fact which may carry home the above principle to those on whom in its abstract form it may produce no effect. It rarely happens that the amount of evil caused by fostering the vicious and the good-for-nothing can be estimated. But in America, at a meeting of the State Charities Aid Association, held on December 18, 1874, a startling instance was given in detail by Dr. Harris. It was furnished by a county on the upper Hudson, remarkable for the ratio of crime and poverty to population. Generations ago there had existed a certain "gutter-child," as she would be here called, known as "Margaret," who proved to be the prolific mother of a prolific race. Besides great numbers of idiots, imbeciles, drunkards, lunatics, paupers, and prostitutes, "the county records show two hundred of her descendants who have been criminals." Was it kindness or cruelty which, generation after generation, enabled these to multiply and become an increasing curse to the society around them?

resisted us, were angry because British "honor" was not maintained by fighting to avenge a defeat, at the cost of more mortality and misery to our own soldiers and their antagonists, can not have so much "enthusiasm of humanity" as protests like that indicated above would lead one to expect. Indeed, along with this quick sympathy which they profess will not let them look with patience on the pains of "the battle of life" as it quietly goes on around, they appear to have a callousness which not only tolerates but enjoys contemplating the pains of battles of the literal kind; as one sees in the demand for illustrated papers containing scenes of carnage, and in the greediness with which detailed accounts of bloody engagements are read. We may reasonably have our doubts about men who are so sensitive that they can not bear the thought of hardships borne, mostly by the idle and improvident, and who, nevertheless, have demanded twenty-nine editions of "The Fifteen Decisive Battles of the World," in which they may revel in accounts of slaughter. Nay, even still more remarkable is the contrast between the professed tender-heartedness and the actual hard-heartedness of those who would reverse the normal course of things that immediate miseries may be prevented, even at the cost of greater miseries hereafter produced. For on other occasions you may hear them, with utter disregard of bloodshed and death, contend that in the interests of humanity at large it is well that the inferior races should be exterminated and their places occupied by the superior races. So that, marvelous to relate, though they can not bear to think of the evils accompanying the struggle for existence as it is carried on without violence among individuals in their own society, they can not only tolerate but can applaud such evils in their intense and wholesale forms when inflicted by fire and sword on entire communities. Not worthy of much respect, then, as it seems to me, is this generous consideration of the inferior at home which is accompanied by unscrupulous sacrifice of the inferior abroad.

Still less respectable appears this extreme concern for those of our own blood which goes along with utter unconcern for those of other blood, when we observe its methods. Did it prompt personal effort to relieve the suffering, it would rightly receive approving recognition. Were the many who express this cheap pity like the few who patiently, week after week, and year after year, devote large parts of their time to helping and encouraging, and occasionally amusing, those who, in some cases by ill-fortune and in other cases by incapacity or misconduct, are brought to lives of hardship, they would be worthy of unqualified admiration. The more there are of men and women who help the poor to help themselves—the more there are of those whose sympathy is exhibited directly and not by proxy, the more we may rejoice. But the immense majority of the persons who wish to mitigate by law the miseries of the unsuccessful and the reckless propose to do this in small measure at their own cost and mainly at the cost of others—

sometimes with their assent but mostly without. More than this is true; for those who are to be forced to do so much for the miserable often equally or more require something doing for them. The deserving poor are among those who are burdened to pay the costs of caring for the undeserving poor. As under the old poor-law the diligent and provident laborer had to pay that the good-for-nothings might not suffer, until frequently under this extra burden he broke down and himself took refuge in the workhouse—as at present it is admitted that the total rates levied in large towns for all public purposes have now reached such a height that they "can not be exceeded without inflicting great hardship on the small shopkeepers and artisans, who already find it difficult enough to keep themselves free from the pauper taint"; * so in all cases the policy is one which intensifies the pains of those most deserving of pity, that the pains of those least deserving of pity may be mitigated. In short, men who are so sympathetic that they can not allow the struggle for existence to bring on the unworthy the sufferings consequent on their incapacity or misconduct, are so unsympathetic that they can, with equanimity, make the struggle for existence harder for the worthy, and inflict on them and their children artificial evils in addition to the natural evils they have to bear!

And here we are brought round to our original topic—the sins of legislators. Here there comes clearly before us the commonest of the transgressions which rulers commit—a transgression so common, and so sanctified by custom, that no one imagines it to be a transgression. Here we see that, as indicated at the outset, Government, begotten of aggression and by aggression, ever continues to betray its original nature by its aggressiveness; and that even what on its nearer face seems beneficence only, shows, on its remoter face, not a little maleficence—kindness at the cost of cruelty. For is it not cruel to increase the sufferings of the better that the sufferers of the worse may be decreased?

It is, indeed, marvelous how readily we let ourselves be deceived by words and phrases which suggest one aspect of the facts while leaving the opposite aspect unsuggested. A good illustration of this, and one germane to the immediate question, is seen in the use of the words "protection" and "protectionist" by the antagonists of free trade, and in the tacit admission of its propriety by free-traders. While the one party has habitually ignored, the other party has habitually failed to emphasize, the truth that this so-called protection always involves aggression; and that the name aggressionist ought to be substituted for the name protectionist. For nothing can be more certain than that, if to maintain A's profit B is forbidden to buy of C, or is fined to the extent of the duty if he buys of C, B is aggressed

* Mr. Chamberlain in "Fortnightly Review," December, 1883, p. 772.

upon that A may be "protected." Nay, aggressionists would much more truly describe the anti-free-traders than the euphemistic title "protectionists"; since, that one producer may gain, ten consumers are fleeced.

Now, just the like confusion of ideas, caused by looking at one face only of the transaction, may be traced throughout all the legislation which forcibly takes the property of this man for the purpose of giving gratis benefits to that man. Habitually when one of the numerous measures thus characterized is discussed, the dominant thought is concerning the pitiable Jones who is to be protected against some evil, while no thought is given to the hard-working Brown who is aggressed upon, often much more to be pitied. Money is exacted (either directly or through raised rent) from the huckster who only by extreme pinching can pay her way, from the mason thrown out of work by a strike, from the mechanic whose savings are melting away during an illness, from the widow who washes or sews from dawn to dark to feed her fatherless little ones; and all that the dissolute may be saved from hunger, that the children of less impoverished neighbors may be educated, and that various people, mostly better off, may read newspapers and novels for nothing! The error of nomenclature is, in one respect, more misleading than that which, as we see, allows aggressionists to be called protectionists; for, as just shown, protection of the vicious poor involves aggression on the virtuous poor. Doubtless it is true that the greater part of the money exacted comes from those who are relatively well-off. But this is no consolation to the ill-off from whom the rest is exacted. Nay, if the comparison be made between the pressures borne by the two classes respectively, it becomes manifest that the case is even worse than at first appears; for, while to the well-off the exaction means loss of luxuries, to the ill-off it means loss of necessaries.

And now see the Nemesis which is threatening to follow this chronic sin of legislators. They and their class, in common with all owners of property, are in danger of suffering from a sweeping application of that general principle practically asserted by each of these confiscating acts of Parliament. For what is the tacit assumption on which such acts proceed? It is the assumption that no man has any claim to his property, not even to that which he has earned by the sweat of his brow, save by permission of the community; and that the community may cancel the claim to any extent it thinks fit. No defense can be made for this appropriation of A's possessions for the benefit of B, save one which sets out with the postulate that society as a whole has an absolute right over the possessions of each member. And now this doctrine, which has been tacitly assumed, is being openly proclaimed. Mr. George and his friends, Mr. Hyndman and his supporters, are pushing the theory to its logical issue. They have been instructed by examples, yearly increasing in number, that the indi-

vidual has no rights but what the community may equitably override; and they are now saying, "It shall go hard but we will better the instruction," and override individual rights altogether.

Legislative misdeeds of the classes above indicated are in large measure explained, and reprobation of them mitigated, when we look at the matter from afar off. They have their root in the error that society is a manufacture; whereas it is a growth. Neither the culture of past times nor the culture of the present time has given to any considerable number of people a scientific conception of a society—a conception of it as having a natural structure in which all its institutions, governmental, religious, industrial, commercial, etc., etc., are interdependently bound—a structure which is in a sense organic. Or if such a conception is nominally admitted, it is not believed in such way as to be operative on conduct. Contrariwise, incorporated humanity is very commonly thought of as though it were like so much dough which the cook can mold at will into pie-crust, or puff, or tartlet. The communist shows us unmistakably that he thinks of the body politic as admitting of being shaped thus or thus at will; and the tacit implication of many acts of Parliament is that aggregated men, twisted into this or that arrangement, will remain as intended.

It may indeed be said that, even irrespective of this erroneous conception of a society as a plastic mass instead of as an organized body, facts forced on his attention hour by hour should make every one skeptical as to the success of this or that proposed way of changing a people's actions. Alike to the citizen and to the legislator, home experiences daily supply proofs that the conduct of human beings balks calculation. He has given up the thought of managing his wife, and lets her manage him. Children on whom he has tried now reprimand, now punishment, now suasion, now reward, do not respond satisfactorily to any method; and no expostulation prevents their mother from treating them in ways he thinks mischievous. So, too, his dealings with his servants, whether by reasoning or by scolding, rarely succeed for long: the falling short of attention, or punctuality, or cleanliness, or sobriety, leads to constant changes. Yet, difficult as he finds it to deal with humanity in detail, he is confident of his ability to deal with embodied humanity. Citizens, not one-thousandth of whom he knows, not one-hundredth of whom he ever saw, and the great mass of whom belong to classes having habits and modes of thought of which he has but dim notions, he has no doubt will act in certain ways he foresees, and fulfill ends he wishes. Is there not a marvelous incongruity between premises and conclusion?

One might have expected that whether they observed the implications of these domestic failures, or whether they contemplated in every newspaper the indications of a social life too vast, too varied, too involved, to be even vaguely pictured in thought, men would have entered

on the business of law-making with the greatest hesitation. Yet in this more than in anything else do they show a confident readiness. Nowhere is there so astounding a contrast between the difficulty of the task and the unpreparedness of those who undertake it. Surely among monstrous beliefs one of the most monstrous is that, while for a mean handicraft, such as shoe-making, a long apprenticeship is needful, the sole thing which needs no apprenticeship is making a nation's laws!

Summing up the results of the discussion, may we not reasonably say that there lie before the legislator several open secrets, which yet are so open that they ought not to remain secrets to one who undertakes the vast and terrible responsibility of dealing with millions upon millions of human beings by measures which, if they do not conduce to their happiness, will increase their miseries and accelerate their deaths?

There is first of all the undeniable truth, conspicuous and yet absolutely ignored, that there are no phenomena which a society presents but what have their origins in the phenomena of individual human life, which again have their roots in vital phenomena at large. And there is the inevitable implication that unless these vital phenomena, bodily and mental, are chaotic in their relations (a supposition excluded by the very maintenance of life) the resulting phenomena can not be wholly chaotic: there must be some kind of order in the phenomena which grow out of them when associated human beings have to cooperate. Evidently, then, when one who has not studied such resulting phenomena of social order undertakes to regulate society he is pretty certain to work mischiefs.

In the second place, apart from *a priori* reasoning, this conclusion should be forced on the legislator by comparisons of societies. It ought to be sufficiently manifest that, before meddling with the details of social organization, inquiry should be made whether social organization has a natural history; and that, to answer this inquiry, it would be well, setting out with the simplest societies, to see in what respects social structures agree. Such comparative sociology, pursued to a very small extent, shows a substantial uniformity of genesis. The habitual existence of chieftainship, and the establishment of chiefly authority by war; the rise everywhere of the medicine-man and priest; the presence of a cult having in all places the same fundamental traits; the traces of division of labor, early displayed, which gradually become more marked; and the various complications, political, ecclesiastical, industrial, which arise as groups are compounded and recompounded by war—quickly prove to any who compares them that, apart from all their special differences, societies have general resemblances in their modes of origin and development. They present traits of structure showing that social organization has laws which override

individual wills; and laws the disregard of which must be fraught with disaster.

And then, in the third place, there is that mass of guiding information yielded by the records of law-making in our own country and in other countries, which still more obviously demands attention. Here and elsewhere attempts of multitudinous kinds, made by kings and statesmen, have failed to do the good intended and have worked unexpected evils. Century after century new measures like the old ones, and other measures akin in principle, have again disappointed hopes and again brought disaster. And yet it is thought neither by electors nor by those they elect that there is any need for systematic study of that legislation which in by-gone ages went on working the ill-being of the people when it tried to achieve their well-being. Surely there can be no fitness for legislative functions without wide knowledge of those legislative experiences which the past has bequeathed.

Reverting, then, to the analogy drawn at the outset, we must say that the legislator is morally blameless or morally blameworthy according as he has or has not acquainted himself with these several classes of facts. A physician who, after years of study, has gained a competent knowledge of physiology, pathology and therapeutics, is not held criminally responsible if a man dies under his treatment; he has prepared himself as well as he can, and has acted to the best of his judgment. Similarly the legislator whose measures produce evil instead of good, notwithstanding the extensive and methodic inquiries which helped him to decide, can not be held to have committed more than an error of reasoning. Contrariwise, the legislator who is wholly or in great measure uninformed concerning these masses of facts which he must examine before his opinion on a proposed law can be of any value, and who nevertheless helps to pass that law, can no more be absolved if misery and mortality result, than the journeyman druggist can be absolved when death is caused by the medicine he ignorantly prescribes.

MODES OF REPRODUCTION IN PLANTS.

By BYRON D. HALSTED, Sc. D.

THE sexual generation of a plant is that stage in its life-history which bears the male and female organs, while the asexual generations are those having no sexuality manifest. The two kinds of generations frequently follow each other in alternate order, when there is what is known as an alternation of generations.

Growing plants continue to increase in size in a well-defined manner for a time, and then a single cell, or a small group of cells, begins on a new line of development. This new growth finally becomes de-

tached from the parent-plant. The offspring may, or may not, be like the parent. Plants which result from similar cells developed in the same manner belong to the same generation. If the original reproductive cells grow into plants without any union with other cells, these plants are asexually produced. If the union of the contents of two or more cells is necessary for further development, there results a sexual product.

It is the purpose of this paper to trace the relative size of the two generations above described, in a number of the higher orders of plants. In doing this, the fact of the alternation will be developed. The series of orders will begin with the humble *Hepaticæ*, and end with the most highly developed of flowering plants. The *Hepaticæ*, or liverworts, are small, flowerless plants of very simple structure, which grow for the most part in moist places upon the bark of trees, surface of long-exposed rocks, earth, etc. One of the leading genera is *Marchantia*, species of which abound on the earth of flower-pots in greenhouses and elsewhere. The leaf-like expansion or thallus is the sexual generation, and bears the male and female organs in depressions of the surface. The male parts, called antheridia, produce spermatozoids, which are spiral, slender bodies, provided with two motile hairs or cilia, as locomotive appendages. The female organs (archegonia) are at first single cells, which by division form flask-like structures, the lower cell of which is the female germ-cell. When this germ is fertilized by the antherozoids, which enter at the neck of the "flask," it undergoes a development, varying somewhat in the different orders, but essentially a sporangium or spore-case is produced, in which are very many spores and slender spiral threads arranged in rows. This sporangium is the second and asexual generation of the liverwort. The complexity of the structure of

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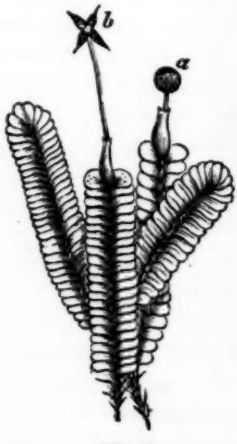

FIG. 2.

the first or leaf-like generation and of the sexual organs and sporangia increases in the hepaticæ group in passing from the lower to the higher forms. In the highest group there are stems with leaves arranged in

rows, and the sporangia are raised on long stalks. Fig. 1 shows at *t* a portion of *Marchantia polymorphia*, with an upright receptacle, *h*, bearing the male organs. In Fig. 2 is seen a stem of *Plagiochila asplenioides*; *a* is a ripe sporangium, and *b* one that has opened.

In the mosses, the next class in the upward scale of plant-life, the spore germinates by producing a fine green thread, which branches and forms a plant much resembling many of the filamentous fresh-water algæ. In the order *Sphagnaceæ* this "alga form" is a flat expansion similar to the sexual generation of many liverworts. Fig. 3 shows

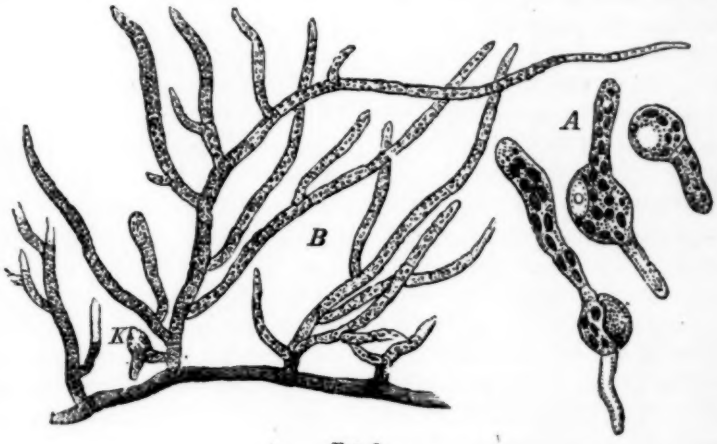

FIG. 3.

the germinating spores of *Funaria hygrometrica*, at A, and the fine branching, green threads (B) that are afterward produced. The true moss-plant, with its small stems, and fine, regularly arranged leaves, originates from specialized cells in the protonema, or alga form. K, in Fig. 3, shows the rudiment of a leaf-bearing axis. On the conspicuous moss-plant, arising from such small beginnings, the sexual organs are borne. They are usually produced in clusters at the ends of the leafy axes. Most mosses have only one sex represented in a single tip, and some species have the separation of the sexes so complete that a plant bears only one kind. Mosses, as well as trees and shrubs, are sometimes monœcious or diœcious. Fig. 4 shows the male and female organs very much magnified. The antheridium, A, is a stalked, club-shaped structure, inclosing a large number of sperm-cells, *b*, each of which produces a spiral spermatozoid, *c*. These minute bodies move rapidly by means of two cilia, and find their way to the neck of the female organ, B. The germ-cell, *b*, to be fertilized, is at the base of the long structure, with a mucilaginous channel, *h*, leading down to it. After the spermatozoids have united with the germ-cell, the latter soon begins a new growth, and a young sporangium results. Fig. 5 shows different stages in the development of the sperm-case; and in

Fig. 6 is seen a vertical section of one fully grown, showing the various parts of theca, calyptera, operculum, etc. In this complicated sporangium, small spores in great numbers are produced, and with their perfection ends the last chapter in the life-history of the moss.

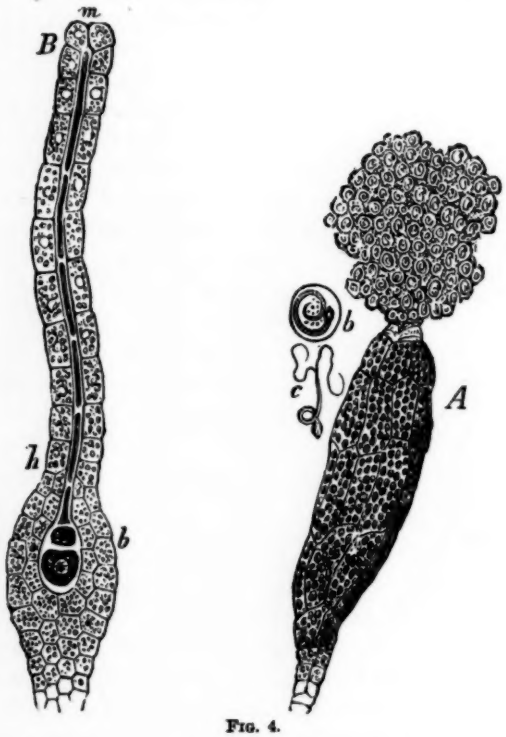

Fig. 4.

The spore produces a fine filamentous growth, from which the true moss-plant develops. This is the sexual generation, and from fertilized germ-cells, which it bears, the asexual generation is produced, consisting of the spore-case, its stalk, and, most important of all, the many spores.

We now come to a more exalted group of plants, and the first of the cryptogams with spiral vessels and other ducts in the wood. The ferns are so familiar to all that any description of their general appearance is unnecessary. The first generation proceeds directly from the spore, and consists of a simple green expansion which is short-lived and very small, not usually exceeding half the size of a small finger-nail. This prothallus, as it is termed, has small, root-like hairs which fix it to the earth or elsewhere. The prothallia are to be seen in large numbers on the sides of flower-pots in neglected greenhouses. Each little green scale is a young fern-plant during its sexual generation. The male and female organs are much the same shape as those of mosses.

Fig. 7 shows a prothallus seen from the under side and much magnified; *h*, are the root-hairs; *an*, antheridia; and *ar*, archegonia. The antheridia produce cork-screw coiled antherozoids which pass to the archegonia and fertilize their germ-cells. The second generation de-

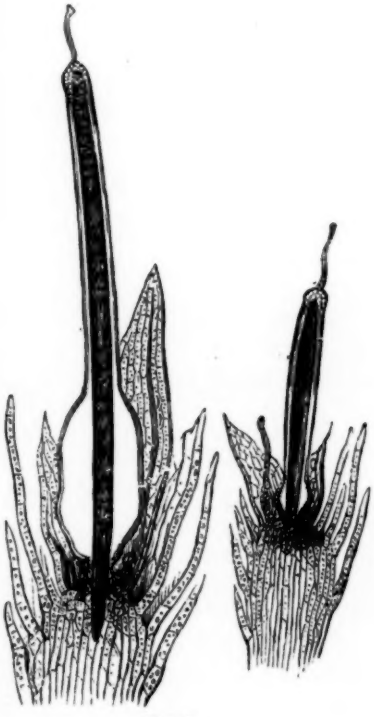

Fig. 5.

Fig. 6.

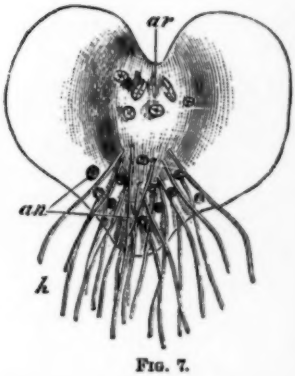

Fig. 7.

velops from the germ-cell, as shown in Fig. 8. By a further growth of stem and fronds, the well-known state of the fern is produced. The spores are borne on the under side or edges of the fronds. In some species the spores are formed only on a portion of the fronds, the others being sterile. The plant commonly known as the fern does not have any male or female parts, and may live for many years, producing countless spores. The sexes are confined to the minute scale, which is so small as to pass unnoticed, and if seen would not suggest its origin or destiny. Dr. Farlow has discovered instances where the prothallia produced fern-plants without the usual process of fertilization. These are only the exceptions which prove the rule.

There is a little group of ferns to which the "adder-tongue" belongs, that has the prothallus underground, consisting of an irregular

mass of colorless cells, which may not exceed one twenty-fifth of an inch in diameter. This group forms another step toward a greater simplicity of the sexual generation in plants. The spores of the *Ophioglossaceæ* are developed less superficially on the fronds than in the lower orders of ferns. This is a morphological point which is worthy of mention here. The whole structure of the asexual generation is more highly developed than in other ferns, while the sexual generation is much reduced and simplified.

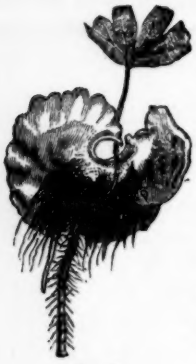

Fig. 8.

The *Equisetaceæ*, or horse-tails, form a small group of flowerless plants, with hollow, jointed stems and cone-like spore-heads (Fig. 9). The scouring-rush, with its rough, grooved stem, is a leading member of this family. The prothallia are small and irregularly branched, and in most species the male and female parts are on separate plants (diœcious). The antheridia-bearing prothallia are much smaller than the female, the latter being sometimes half an inch in length. The structure of the male and female organs is much the same as in ferns. The antherozoids are larger, and the archegonia are more deeply situated in the prothallus. The conspicu-

Fig. 9.

Fig. 10.

ous horse-tail develops from the fertilized germ-cell, and constitutes the spore-bearing asexual generation. In some species a colorless or brownish stem comes up in early spring, which bears the spores on whorls of modified leaves, and afterward perishes. Later in the spring the green stems arise. This shows a greater differentiation in the asexual generation.

Next above the horse-tails come the *Rhizocarpeæ*, a small cryptogamic group of water-plants, inhabiting ditches, streams, etc. Thus far, in our upward course, we have found only one kind of spore. Here there are two sorts, the large and the small. The former produce archegonia, and are therefore essentially female, while the smaller spores are male, and produce antherozoids. These spores are formed in spore-cases, termed sporocarps. Fig. 10 shows a plant of *Marsilia salvatrix*, reduced one half; K is the terminal bud; *b b*, leaves; *f f*, sporocarps. In these last the spores of both sizes are produced. The contents of the small or male spores divide and develop into a number of antherozoids, which afterward escape through a rupture in the spore-wall. A small portion of the spore does not take part in this formation of antherozoids, and may be considered the prothallus, In the large or female spore the prothallus is larger, and only one end of the spore bears a single archegonium. In Fig. 11, at A, is shown

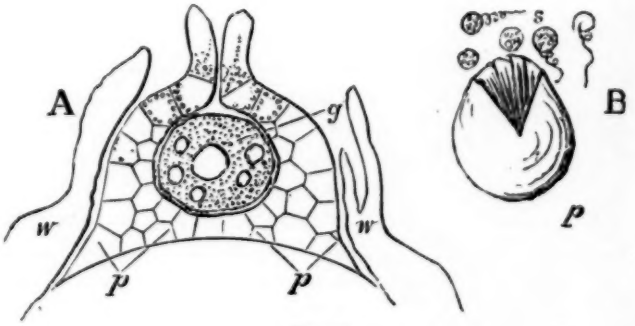

Fig. 11.

a vertical section of the archegonium end of a large spore; *w w* are parts of the ruptured spore-wall; *p p* is the prothallus, and *g* the germ-cell. At B is a male spore of the same species, with its wall ruptured, and the corkscrew-like antherozoids, *s*, escaping. The second generation soon develops from the fertilized germ-cells, and produces the mature plant. It is seen that the sexual generation in the Marsilia group is reduced to two kinds of spores, with their rudimentary prothallia. In another branch of the *Rhizocarpeæ*, while in most features the life-history is as just described, there is a further differentiation in the sporocarps. The male and female spores are produced in separate sporocarps. Fig. 12 shows a section through three spore-cases, two

of them bearing the small males pores, and the third, *a*, the large female spores.

In the next higher group, as arranged by botanists, we find the club-mosses; these are common plants with trailing or upright very leafy stems. Fig. 13, A, shows the tip of a spore-bearing branch, natural size, and B a longitudinal section much enlarged. The large spores are borne in sporangia on one side, while the small ones are on the left. The differentiation has now reached the place where there is a definite arrangement of the sporangia on the plant bearing them. In the development of the male spores the cells in which the antherozoids form are not produced directly from the spore-contents. This is a valuable link in the chain of relationship which binds this group with higher plants—in fact, helps to bridge what gulf there may have been thought existing between the flowerless and flowering plants. The ripe male spore-contents are changed into a few cells, one of which remains sterile and is considered the prothallus, while from the other cells—which taken as a whole constitute the antheridium—the cells which afterward bear the antherozoids are formed. In the genus *Selaginella* the female spore produces a small prothallus, as shown at 1, Fig. 14. The portion above *d d*, in this cross-section of the spore, is the prothallium, and at *e e* are two embryo plants. At 2 is a young archegonium not opened; 3 shows one further advanced, with the fertilized germ-cell divided. A is a male spore, showing the cell-division; D is a later state of the same, with the large antheridium filled with sperm-cells. The rudimentary prothallus is at *v*. The female is still more simple in *Isoetes*, shown in Fig. 15: 1 is the longitudinal section of the female spore, with an archegonium, *a r*, at the top; 2 shows the early differentiation of cells into archegonia, *a r*, *a r*, with their germ-cells, *g g*; 3, 4, and 5 show successive stages in the development of the germ-cell.

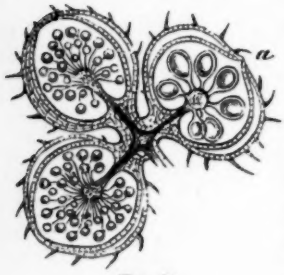

FIG. 12.

FIG. 13.

There is a close resemblance to the embryo sac of *Gymnosperms* (pines, spruces, etc.). The prothallus is very much reduced, and pro-

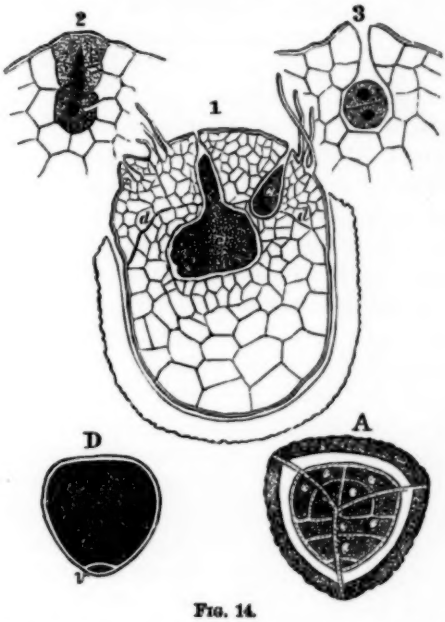

FIG. 14.

jects through the slit in the spore-covering. In the development of the female germ-cell after fertilization, there is an elongation of the upper part (see *e*, Fig. 14), forming the part called the suspensor, a

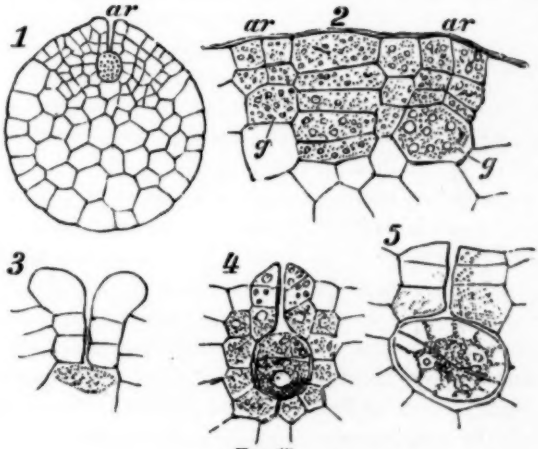

FIG. 15.

body which is not found in other cryptogams, but is present in embryos of flowering plants.

We now pass to phenogamous or flowering plants, in which the

small male spore of the higher cryptogams takes the name of pollen-grains, and the larger female spore is known as the embryo sac. The latter does not sever its connection with the mother-plant until after an embryo plant has formed. On this account the prothallium—which we have seen as an independent structure in ferns and diminishing gradually as we ascended in the scale of flowerless plants—is here but feebly developed. The flower-bearing plant, whether herb, shrub, or tree, is the asexual generation producing two kinds of structures, which, by their development and union of parts, produce a plant like the one from which the sexual generation sprang. The pollen-grain is usually a small spherical or oval body that, when mature, separates from the case (anther) in which it was formed. Figs. 16 shows the form of some simple pollen-grains. Grain A shows the rudimentary prothallium as a small cell, *y*; B is a pollen-grain forming the tube. Much the same is seen at C and D, excepting that the prothallium is made up of three small cells. In structure and function these pollen-grains are almost identical with the male spores of higher cryptogams. The embryo sac is more or less surrounded by the substance of the parent-plant, and develops within itself a prothallus of small size which is known as the endosperm, and is a store-house of nourishing matter for the young embryo. One or more cells form the homologue of the archegonia in higher cryptogams with its female germ. The male cell or pollen-grain no longer develops a number of mobile, fertilizing antherozoids or spermatozoids; but, instead, the whole pollen-grain passes to a receptive surface (stigma) situated somewhere near the female organ, from which it sends out a tube that penetrates the tissue provided for its passage (style) until it reaches its destination and mingles its contents with those of the female cell. Circumstances obtain in the flowering plants which render mobile bodies like spermatozoids worthless as a means of fertilization. In many cases the male element needs to pass from one tree to another, and even from one country to another. The first observed result of fertilization is the formation of the suspensors, mentioned under *Selaginella*. At the lower end of the suspensor the young plantlet is formed with its one or more small seed-leaves and a short root and stem. In this growth the food-material in the endosperm is frequently entirely exhausted. The ovule, as the female cell with its immediate surrounding tissue is

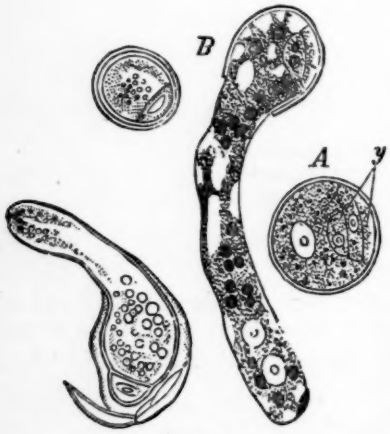

FIG. 16.

termed, becomes inclosed with one or more coats of varying thickness, and, when the whole structure has reached maturity and is ready to separate from the parent-plant, we have the familiar body known as a seed. The seed is an independent plant-structure designed to develop into a mature herb, shrub, or tree, when the conditions are favorable for its germination and growth.

The lowest class of flowering plants is the *Gymnosperms*—which includes the cycads and cone-bearing plants. The ovules are naked, and the embryo develops considerable endosperm. This corresponds to the prothallus of higher cryptogams, as in it the corpuscula, which correspond with archegonia, are formed. The pollen-grains are several-celled, thus suggesting a prothallus, especially as only a part of the grain takes part in the formation of the tube and the male fertilizing fluid. The gymnosperms evidently occupy an intermediate place between the higher cryptogams and the angiosperms or flowering plants with their ovules inclosed in an ovary. This last class contains the great mass of plants with evident floral organs, and is divided into the exogens, like the oak, apple, and rose, and the endogens, illustrated by the grasses and cereal grains.

The points that interest us most in the present consideration are, that, unlike the gymnosperms, the ovules are inclosed in an ovary; the endosperm forms in the embryo sac after fertilization, and the pollen-grain sends out its tube without previous cell-division. The pollen-grains often have no rudimentary prothallus. The first result of fertilization is the formation of a cellulose wall around the germ-cell. This cell soon divides, forming the suspensor at the lower end, from which the embryo plantlet is developed. The endosperm-cells form at the same time at the opposite end of the embryo sac. Fig. 17, A, shows a longitudinal section of a young ovule shortly after fertilization. The embryo sac is at *e*, with a small embryo at the left end, and free endosperm-cells formed at the other. The embryo is shown more magnified at B, and at C is seen the same more advanced. The endosperm is rich in food-materials for the growing embryo, and may be entirely absorbed and the space occupied by the latter.

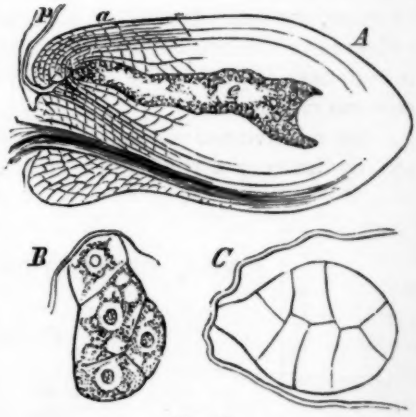

FIG. 17.

It now remains for us to determine the extent of the sexual generation in the flowering plants. Among gymnosperms it is not difficult to see that it consists of the pollen-grain and the embryo sac with its endo-

sperm. The male prothallus is reduced and rudimentary, and one cell of the pollen-grain, representing the antheridium, produces a tube instead of antherozoids. The endosperm is the female prothallus, and in it the germ-cell develops. The asexual generation is the plant that grows from the fertilized germ. In the angiosperms the sexual generation is reduced to its simplest form, namely, a single cell for the male part, and one or a few cells for the female.

We thus see that the alternation of generation, viewed in the light of its presentation among mosses and ferns, practically disappears in the higher flowering plants. The sexual generation is so reduced and merged with the asexual that the two seem to become one, and, were it not that the gradual simplifying of this generation may be traced, it would not be thought to exist.

If we recapitulate, in the reverse order, it is easy to evolve a conspicuous, independent plant from the single-celled pollen-grain, and a similar self-supporting plant from the simple embryo sac. The first step back is to the gymnosperms, where the ovules are not in ovaries, and the embryo sac has a rudimentary prothallus in the endosperm. The pollen-grain is made up of more then one cell. From this group we pass to the *Selaginellæ*, in which we have the female spore, with its rudimentary prothallus, and the smaller male spore, having one cell for the prothallus, the remaining ones forming the antherozoids. Descending to the *Rhizocarpeæ*, both the spores increase in size and complexity. Further back we come to the higher orders of ferns, with but one kind of spore, the small prothallus, bearing both sexual organs. The lower orders have this sex-bearing generation much more developed. In the mosses and *Hepaticæ* the sexual generation surpasses the asexual in size and complexity.

The relative size of the two generations might be represented to the eye by drawing a rectangle with a diagonal, Fig. 18. One triangle

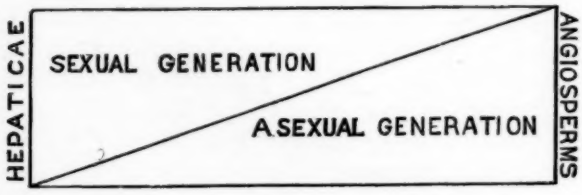

FIG. 18.

would indicate the size and complexity of the sexual generation, while the other represented the asexual generation. The sexual generation diminishes from the *Hepaticæ* to the angio-sperms, while the asexual generation increases.

The engravings here employed are from treatises on botany by Sach, Prantl, and Bessey, to whom the writer is also indebted for many of the facts brought together.

EVOLUTION AND DISSOLUTION OF THE NERVOUS SYSTEM.*

By J. HUGHLINGS JACKSON, M. D., F. R. S.

MR. PRESIDENT AND GENTLEMEN: The doctrine of evolution daily gains new adherents. It is not simply synonymous with Darwinism. Herbert Spencer applies it to all orders of phenomena. His application of it to the nervous system is most important for medical men. I have long thought that we shall be very much helped in our investigations of diseases of the nervous system by considering them as reversals of evolution—that is, as dissolutions. Dissolution is a term I take from Spencer as meaning the reverse of the process of evolution. The subject has been worked at for many years. About half a century ago, Laycock applied the doctrine of reflex action to the brain. Sir Charles Bell, in speaking of degrees of drunkenness, and Baillarger, in remarking upon aphasia, have pointed out that there is a reduction from the voluntary toward the automatic. The late Dr. Anstie's researches † are perhaps the most valuable of all contributions toward the study of diseases of the nervous system as examples of dissolution, although he did not use that term. I refer also with great respect to the most valuable and highly original work which Ross, Ribot, and Mercier have done in the same direction. The brilliant researches of Hitzig and Ferrier, besides their obvious great value in other ways, are of very great value in supporting the doctrines of evolution and dissolution of the nervous system. In this connection I gladly mention with great respect a recent valuable paper on cerebral localization by Dr. Sharkey.

Wishing as soon as possible to give illustrations of dissolution, I will make the necessary preliminary as short as I can. I speak only of the most striking aspects of evolution and dissolution, leaving entirely out of account some very important factors specially insisted upon by Herbert Spencer. I regret that time renders it necessary for me to simplify my subject by serious omissions. Spencer, to whom I am under the deepest obligation, must not be judged by my present application of his doctrines, or rather of part of them. I have to ask pardon for the use in this lecture of some popular terms. "Most voluntary," though it has a technical sound, is, when used in contrast to "most automatic," a popular term, and later on it will be discarded. I have also to acknowledge an omission; I speak for the most part of the cerebral system only, almost ignoring all divisions of the cerebel-

* This is the first of the Croonian Lectures, delivered before the Royal College of Physicians by J. Hughlings Jackson, M. D., F. R. S., Fellow of the Royal College of Physicians, Physician to the Hospital for the Paralyzed and Epileptic, and to the London Hospital.

† "Stimulants and Narcotics."

lar system. For the present I neglect the absolute distinction there really is between mental and nervous states.

Beginning with evolution, and dealing only with the most conspicuous parts of the process, I say of it that it is an ascending development in a particular order. I make three statements, which, although from different stand-points, are about the very same thing: 1. Evolution is a passage from the most to the least organized—that is to say, from the lowest well-organized centers up to the highest least organized centers. Putting this otherwise, the process is from centers comparatively well organized at birth up to those, the highest centers, which are continually organizing through life. 2. Evolution is a passage from the most simple to the most complex; again from the lowest to the highest centers. There is no inconsistency whatever in speaking of centers being at the same time most complex and least organized. Suppose a center to consist of but two sensory and two motor elements, if the sensory and motor elements be well joined, so that "currents flow" easily from the sensory into the motor elements, then that center, although a very simple one, is highly organized. On the other hand, we can conceive a center consisting of four sensory and four motor elements, in which, however, the junctions between the sensory and the motor elements are so imperfect that the nerve-currents meet with much resistance. Here is a center twice as complex as the one previously spoken of, but of which we may say that it is only half so well organized. 3. Evolution is a passage from the most automatic to the most voluntary. The triple conclusion come to is, that the highest centers, which are the climax of nervous evolution, and which make up the "organ of mind," or physical basis of consciousness, are the least organized, the most complex, and the most voluntary. So much for the positive process by which the nervous system is "put together"—evolution. Now for the negative process, "the taking it to pieces"—dissolution.

Dissolution being the reverse of the process of evolution just spoken of, little need be said about it here. It is a process of undevelopment; it is a "taking to pieces" in the order from the least organized, the most complex, and the most voluntary, toward the most organized, most simple, and most automatic. I have used the word "toward," for if dissolution were up to and inclusive of the most organized, etc., if, in other words, dissolution were total, the result would be death. I say nothing of total dissolution in these lectures. Dissolution being partial, the condition in every case of it is duplex. The symptomatology of nervous diseases is a double condition; there is a negative and there is a positive element in every case. Evolution not being entirely reversed, some level of evolution is left. Hence the statement "to undergo dissolution" is rigidly the equivalent of the statement "to be reduced to a lower level of evolution." In more detail, loss of the least organized, most complex, and most voluntary implies the reten-

tion of the more organized, the less complex, and the more automatic. This is not a mere truism ; or, if it be, it is one that is often neglected. Disease is said to cause the symptoms of insanity. I submit that disease only produces negative mental symptoms answering to the dissolution, and that all elaborate positive mental symptoms (illusions, hallucinations, delusions, and extravagant conduct) are the outcome of activity of nervous elements untouched by any pathological process—that they arise during activity on the lower level of evolution remaining. The principle may be illustrated in another way without undue recapitulation. Starting this time with health, the assertion is that each person's normal thought and conduct are, or signify, survivals of the fittest states of what we may call the topmost layer of his highest centers, the normal highest level of evolution. Now, suppose that from disease the normal highest level of evolution (the topmost layer) is rendered functionless. This is the dissolution, to which answer the negative symptoms of the patient's insanity. I contend that his positive mental symptoms are still the survival of his fittest states—are survivals on the lower, but then highest, level of evolution. The most absurd mentation and most extravagant actions in insane people are the survival of their fittest states. I say "fittest" not "best" ; in this connection the evolutionist has nothing to do with good or bad. We need not wonder that an insane man believes in what we call his illusions ; they are his perceptions. His illusions, etc., are not caused by disease, but are the outcome of activity of what is left of him (of what disease has spared), of all there then is of him ; his illusions, etc., are his mind.

After this brief sketch I mention what may appear to be a drawback. Scarcely ever, if ever, do we meet with a case of dissolution which we can suppose to be the exact opposite of evolution. Often enough, however, do we meet with its near opposites. I will try to dissipate any difficulties that may arise. We make two broad divisions of cases of dissolution—uniform and local.

In uniform dissolution the whole nervous system is under the same conditions or evil influence, the evolution of the whole nervous system is comparatively evenly reversed. In these cases the whole nervous system is "reduced," but the different centers are not equally affected. An injurious agency, say alcohol, taken into the system, flows to all parts of it, but the highest centers, being least organized, "give out" first and most ; the middle centers, being more organized, resist longer, and the lowest centers, being most organized, resist longest. Did not the lowest centers for respiration and circulation resist more than the highest do, death by alcohol would be a very common thing. Another way of stating the foregoing is to say that increasing uniform dissolution follows a "compound order." Three stages may be rudely symbolized thus, using the initial letters of highest, middle, and lowest centers. First stage or depth of dissolution, h ; second stage, h_2+m ;

third stage, h_3+m_3+l; etc. Although I shall say very little later on of involvement of middle and lowest centers in cases of uniform dissolution, it is most important, especially with regard to clear notions on localization, to recognize that the order of dissolution is a compound order.

The next division is local dissolution. Obviously disease of a part of the nervous system could not be a reversal of the evolution of the whole; all that we can expect is a local reversal of evolution, that there should be loss in the order from voluntary toward automatic in what the part diseased represents. Repeating in effect what was said on uniform dissolution, it is only when dissolution occurs in all divisions of the highest centers that we can expect a reduction from the most voluntary of all toward the most automatic of all. Dissolution may be local in several senses. Disease may occur on any evolutionary level on one side, or on both sides; it may affect the sensory elements chiefly, or the motor elements chiefly. It must be particularly mentioned that there are local dissolutions of the highest centers. It will be granted that in every case of insanity the highest centers are morbidly affected. Since there are different kinds as well as degrees of insanity, for examples, general paralysis and melancholia, it follows, of necessity, that different divisions of the highest centers are morbidly affected in the two cases. Different kinds of insanity are different local dissolutions of the highest centers.

I now come to give examples of dissolution. I confess that I have selected cases which illustrate most definitely, not pretending to be able to show that all the diseases of which we have a large clinical knowledge exemplify the law of dissolution. However, I instance very common cases, or cases in which the pathology has been well worked out; they are cases dependent on disease at various levels from the bottom to the top of the central nervous system. Most of them are examples of local dissolution:

1. Starting at the bottom of the central nervous system, the first example is the commonest variety of progressive muscular atrophy. We see here that atrophy begins in the most voluntary limb, the arm; it affects first the most voluntary part of that limb, the hand, and first of all the most voluntary part of the hand; it then spreads to the trunk, in general to the more automatic parts. To speak of a lower level of evolution in this case is almost to state a barren truism. At a stage when the muscles of the hand only are wasted, there is atrophy of the first or second dorsal anterior horn; the lower level of evolution is made up of the higher anterior horns for muscles of the arm. This statement, however, is worth making, for it shows clearly that by higher and lower is meant anatomico-physiologically higher or lower.

2. Going a stage higher we come to hemiplegia, owing to destruction of part of a plexus in the mid-region of the brain. Choosing the

commonest variety of hemiplegia, we say that there is loss of more or fewer of the most voluntary movements of one side of the body; we find that the arm, the more voluntary limb, suffers the more and longer; we find, too, that the most voluntary part of the face suffers more than the rest of the face. Here we must speak particularly of the lower level of evolution remaining; strictly we should say collateral and lower. We note that, although unilateral movements (the more voluntary) are lost, the more automatic (the bilateral) are retained. Long ago this was explained by Broadbent. Subsequent clinical researches are in accord with his hypothesis. The point of it is that the bilateral movements escape in cases of hemiplegia in spite of destruction of some of the nervous arrangements representing them; the movements are doubly represented—that is, in each half of the brain. Hemiplegia is a clear case of dissolution, loss of the most voluntary movements of one side of the body with persistence of the more automatic movements.

3. The next illustration is paralysis agitans. Apart from all speculation as to the seat of this disease, the motorial disorder illustrates dissolution well. In most cases the tremor affects the arm first, begins in the hand, and in the thumb and index-finger. The motorial disorder in this disease becomes bilateral; in an advanced stage paralysis agitans is double hemiplegia with rigidity—is a two-sided dissolution.

4. Next we speak of epileptiform seizures which are unquestionably owing to disease in the mid-region of the brain (middle motor centers). Taking the commonest variety, we see that the spasm mostly begins in the arm, nearly always in the hand, and most frequently in the thumb or index-finger, or both; these two digits are the most voluntary parts of the whole body.

5. [The next illustration was by cases of temporary paralyses after epileptiform seizures.]

6. Chorea is a disease in which the limbs (the most voluntary parts) are affected more than the trunk (the more automatic parts), and the arms (the more voluntary limbs) suffer more than the legs. The localization of this disease has not been made out; symptomatically, however, it illustrates dissolution. Chorea has a special interest for me. The great elaborateness of the movements points to disease "high up"—to disease on a high level of evolution. Twenty years ago, from thinking on its peculiarities, it occurred to me that some convolutions represent movements—a view I have taken ever since.

7. Aphasia. This well illustrates the doctrine of dissolution, and in several ways. We will consider a case of complete speechlessness: (*a.*) There is loss of intellectual (the more voluntary) language, with persistence of emotional (the more automatic) language. In detail the patient can not speak, and his pantomime is of a very simple kind; yet, on the other hand, he smiles, frowns, varies the tones of his voice (he may be able to sing), and gesticulates as well as ever. Gesticula-

tion, which is an emotional manifestation, must be distinguished from pantomime, which is part of intellectual language. (*b.*) The frequent persistence of "Yes" and "No," in the case of patients who are otherwise entirely speechless, is a fact of extreme significance. We see that the patient has lost all speech, with the exception of the two most automatic of all verbal utterances. "Yes" and "No" are evidently most general, for they assent to or dissent from any statement. In consequence of being frequently used, the correlative nervous arrangements are of necessity highly organized, and, as a further consequence, they are deeply automatic. (*c.*) A more important, though not more significant, illustration is that the patient who can not get out a word in speech nevertheless understands all that we say to him. Plainly this shows loss of a most voluntary service of words, with persistence of a more automatic service of words. We find illustrations in small corners. (*d.*) There are three degrees of the utterance "No" by aphasics. A patient may use it emotionally only—a most automatic service; another patient may also be able to reply correctly with it —a less automatic but still very automatic service. (Here there is some real speech.) There is a still higher use of it, which some aphasics have not got. A patient who can reply "No" to a question may be unable to say "No" when told to do so. You ask the aphasic, "Is your name Jones?" he replies, "No." You tell him to say "No," he tries and fails. You ask, "Are you a hundred years old?" He replies, "No." You tell him to say "No." He can not. While not asserting that the inability to say "No" when told is a failure in language, it is asserted that such inability with retention of power to use the word in reply illustrates dissolution. (*e.*) A patient who is speechless may be unable to put out his tongue when told to do so; that he knows what is wanted is sometimes shown by his putting his finger in his mouth to help out the organ. That the tongue is not paralyzed in the ordinary sense is easily proved. The patient swallows well, which he could not do if his tongue were as much paralyzed as "it pretends to be." Besides, on other occasions he puts out his tongue, for example, to catch a stray crumb. Here is a reduction to a more automatic condition; there is no movement of the tongue more voluntary than that of putting it out when told.

[The lecturer then remarked on swearing and on the utterance of other and innocent ejaculations by aphasics, remarking that some of these utterances had elaborate propositional structure but no propositional value. The patients could not repeat, say, what under excitement they uttered glibly and well. He spoke next of the frequent retention of some recurring utterance by aphasics, such as "Come on to me." These were not, from the mouth of the aphasic, of any propositional value, were not speech. He had no explanation to offer of these, but stated the hypothesis that they were the words the patient was uttering, or was about to utter, at the time he was taken ill.]

8. So far I have spoken of local dissolution occurring on but one-half of the nervous system on different levels. Coming to the highest centers I speak of uniform dissolutions—of cases in which all divisions of these centers are subjected to the same evil influence. I choose some cases of insanity. In doing this I am taking up the most difficult of all nervous diseases. I grant that it is not possible to show in detail that they exemplify the principle of dissolution, but choosing the simplest of these most complex cases we may show clearly that they illustrate it in general. I take a very commonplace example—delirium in acute non-cerebral disease. This, scientifically regarded, is a case of insanity. In this, as in all other cases of insanity, it is imperative to take equally into account not only the dissolution but the lower level of evolution that remains. The patient's condition is partly negative and partly positive. Negatively, he ceases to know that he is in hospital, and ceases to recognize persons about him. In other words, he is lost to his surroundings, or, in equivalent terms, he is defectively conscious. We must not say that he does not know where he is because he is defectively conscious; his not knowing where he is, is itself defect of consciousness. The negative mental state signifies, on the physical side, exhaustion, or loss of function, somehow caused, of some highest nervous arrangements of his highest centers. We may conveniently say that it shows loss of function of the topmost layer of his highest centers. No one, of course, believes that the highest centers, or any other centers, are in layers; but the supposition will simplify exposition. The other half of his condition is positive. Besides his not knowings, there are his wrong knowings. He imagines himself to be at home or at work, and acts as far as practicable as if he were; ceasing to recognize his nurse as a nurse, he takes her to be his wife. This, the positive part of his condition, shows activity of the second layer of his highest centers; but which, now that the normal topmost layer is out of function, is the then highest layer; his delirium is the "survival of the fittest states," on his then highest evolutionary level. Plainly, he is reduced to a more automatic condition. Being (negatively) lost, from loss of function of the highest, latest developed, and least organized, to his present "real" surroundings, he (positively) talks and acts as if adjusted to some former "ideal" surroundings, necessarily the more organized.

I now make some general remarks on the eight illustrations, in order to prevent certain misunderstanding. It is asserted, again, that each of the eight cases is a different dissolution. All that is meant is that each shows a reduction from the voluntary toward the automatic in what the center, or part of it, which is diseased, represents. If we take extreme cases, the case of progressive muscular atrophy and the case of insanity (delirium in acute non-cerebral disease), we say that the two are alike, because in each there is reduction to a more automatic condition, and we say, too, that they are very unlike, the

parts of the nervous system morbidly affected being exceedingly different.

I have so far almost ignored the distinction between nervous states and mental states. Now, if the case of insanity be considered as a series of mental phenomena only, it would be absurd to compare or even to contrast it with progressive muscular atrophy, which is a series of physical phenomena only. But no difficulty can arise if it be understood that insanity, or "disease of the mind," is with medical men disease of the highest nervous centers revealing itself in a series of mental phenomena. We compare and contrast disease of the highest centers with disease of some anterior horns (some lowest centers) revealing itself in atrophy of certain muscles. But, acknowledging this, it may be said that the two things are so exceedingly different that it is frivolous to compare or even to contrast them on any basis. Yet, no one denies that each is a morbid affection of the central nervous system; this being granted, the rejoinder to those who insist on the extreme unlikeness is that the lesion in one is at the very bottom, in the other at the very top, of the central nervous system; two lesions can not possibly be farther apart in the central nervous system. Still it may be said that classification, on the principle of dissolution, if true, is of no value; that it is of no use making an orderly ascending series from progressive muscular atrophy to insanity—of no use showing that progressive muscular atrophy is reduction to a more automatic condition in a small corner on the lowest level, that hemiplegia is such reduction on a larger scale higher up, and that insanity is such a reduction on the topmost level, and on the largest scale—that even if this kind of work could be thoroughly well done it is not worth any one's while to do it. I grant that such a classification is not of direct value, but yet I think it of much indirect value for clinical purposes. We require in our profession two kinds of classification. The use of two classifications may be easily illustrated. There is a classification, or strictly an arrangement, of plants by the farmer for practical purposes, and there is a classification of plants by the botanist for the advancement of biology. I submit that there is no more incongruity in classing together progressive muscular atrophy and insanity upon the basis mentioned than there is in classifying the bamboo with common grass, or the hart's-tongue with the tree-fern in a botanist's garden. Such kind of classification of plants would be absurd in a farm or kitchen-garden, and so would a classification of diseases of the nervous system upon the principle of dissolution be absurd in an asylum or in the wards of a hospital. I know of no other basis on which cases of insanity, diseases of the highest centers, can be studied comparatively with non-mental diseases of the nervous system—diseases of lower centers.

I next speak of different depths of dissolution. The deeper the dissolution the shallower the level of evolution remaining. In hemi-

plegia, owing to lesion of the internal capsule, there are, according to the gravity of the lesion, three degrees or depths (of course the division into three degrees is arbitrary). In the first degree there is some paralysis of the face, arm, and leg; in the second degree there is more paralysis of these parts, and, in addition, there is a greater range of paralysis; the patient's head and eyes are turned from the side paralyzed. Here is illustrated what I call "compound order." The difference between the two degrees is not that in the second there is more paralysis only, nor that there is a greater range of paralysis only, but in both respects; there is more paralysis of the parts affected in the first degree and extension of range of paralysis to parts beyond them. An adequate doctrine of localization has to account for such increase of paralysis in compound order on increasing gravity of lesions. In the third degree of, or rather beyond, hemiplegia there is universal immobility. In this degree the patient has lost consciousness, and this loss may be said to explain why he does not move the other or "second" side of his body. I hope to show later that explanations of materialistic states by psychical states are invalid. I wish here to bring evidence in support of the opinion I have long held, that all parts of both sides of the body are represented in each half of the brain. The view I take is simply an extension of Broadbent's hypothesis, already referred to. My supposition is that the limbs of the two sides are very unequally represented in each half of the brain, while the bilaterally acting muscles are very nearly equally represented in each half. Evidence that at least some parts of both sides of the body are represented in each half of the brain is that consecutive to a negative lesion of one internal capsule there is wasting of nerve-fibers "descending" into both sides of the spinal cord.

Degrees of epileptiform seizures illustrate different depths of dissolution. There are degrees of these from (to take an example) spasm of the thumb and index-finger to universal convulsion.* That these degrees are compound is very evident. The first stage of the fit is, to speak roughly, that the arm is a little affected; the second stage is that the arm is more affected, and the face a little; the third stage is that the arm is most affected, the face much, and the leg a little. This compound order of spreading, which any adequate doctrine of localization has to account for, may be symbolized thus: a, then a_1+f, then a_3+f_2+l, etc. There are degrees beyond this to universal spasm; these cases I submit supply further evidence that both sides of the body are represented in each half of the brain. Certain experiments of Franck and Pitres† bear in a most important way on the question

* I am not speaking of epileptic attacks, which depend, I think, on discharges beginning in parts of centers of a higher, the highest, level of evolution. A man long subject to very limited epileptiform seizures may at length have seizures beginning in the same way, and becoming universal, but these are not epileptic seizures, they are only more severe epileptiform seizures.

† "Archives de Physiologie," 15 Août, 1883, No. 6.

as to double representation. After exposing the so-called motor region * of each half of the brain of a dog, they removed the motor region on one half, and then found that faradization of the "arm-center" on the half intact (left) produced universal convulsion; they found, too, that the spasm followed a particular order—that it affected the right arm (so to call it), then the right leg, then the left leg, and then the left arm.† Here seems to be evidence that both sides of the body are represented in each half of the brain, and also that the two sides are differently represented in each half. The distinguished French physicians to whose observations I have referred hold, I must mention, that "*le cerveau commence l'attaque, la protubérance, le bulbe et la moëlle la généralisent.*" If this be so, still proof is given that movements of all parts of the body are under command of, if not represented fully in, each half of the brain. This is a matter of extreme importance for the doctrines of evolution and dissolution. The evidence, as I read it, is that the middle motor centers (a discharge beginning in parts of which causes epileptiform seizures) of each half of the brain represent movements of both sides of the body. Other facts will, I think, show that the highest motor centers rerepresent in more intricate combinations all that the middle centers have represented in simpler combinations; a discharge beginning in part of these more evolved centers produces an epileptic seizure, which is, so to speak, a "more evolved convulsion" than an epileptiform seizure.

[In the remainder of the lecture many degrees of aphasia were instanced, to illustrate again different depths of dissolution and different shallows of evolution remaining, and also to illustrate the dual symptomatology of disease. The wrong words uttered by a patient who has "defect of speech" are owing to activities of healthy nervous arrangements, while the disease is answerable only for the patient's not saying the right words. The states comparable in a case of "defect of speech" with the states in the case of another aphasic who can only say "No" are: (1) negatively, the inabilities in the former to say the right words with the latter's speechlessness, and (2) positively, the utterance of numerous wrong words by the former with the retention of "Yes" and "No" only by the latter. In the former the dissolution is slight, and the level of evolution very high; in the latter the dissolution is deep, and the level of evolution very shallow.]—*The Lancet.*

* I say "so-called motor region" not because I deny that the parts in this region are motor—I call them the middle motor centers—but because I believe the parts in front to be motor also, to be the highest motor centers.

† "L'epilepsie peut donc se généraliser malgré la destruction préalable de la zone motrice d'un côté, malgré la section longitudinale complete du corps calleux." (Franck and Pitres.)

THE POLE AND WIRE EVIL.

By OLIVER E. LYMAN.

WHEN any system of business is so conducted as to arouse a feeling of opposition on the part of right-minded citizens generally, it is safe to say that some evil exists, which renders the immediate reformation of that system, in whole or in part, a matter of public importance. Judged by this standard, our telegraphic and electrical system would seem to be in need of reformation. That it has evil features no one can deny, and nothing about it, perhaps, is more obnoxious than the method at present in vogue in cities of constructing lines overground—a method which has increased in obnoxiousness with the recent remarkable growth and expansion of the electrical system.

The mode of construction has not been conformed to the changed conditions which this growth, simultaneously with the progress of civilization, has brought about. The same method of hanging wires on posts which was introduced by Professor Morse has been persevered in ever since, regardless of the fact that the conditions which rendered his single line across an open country, twoscore years ago or so, innocent and proper, are not the same in our densely-built and populated cities of to-day. Ignoring other causes of change, the telegraphic business, most of which is conducted in cities, has wonderfully increased. In place of his one company there were in 1880 seventy-seven telegraphic and one hundred and forty-eight telephone companies in the United States, which numbers have, since that time, been greatly increased by the more general introduction of the system of telephonic communication and the incorporation of many electric-light companies, to say nothing of an increase in telegraphic associations. The single wire from Washington to Baltimore had increased in 1880 to 325,517 miles of wire, 34,305 of which were operated by the telephone companies, and in October, 1883, one company alone, the Western Union, was operating 432,726 miles of wire, nearly enough to reach from the earth to the moon and back again. This same company in 1866 used only 75,686 miles of wire, so that it will be seen it has nearly six times as much wire strung over the country as it had then, and these 432,726 miles of wire are exclusive of 144,294 miles of cables and poles. Of the latter ungainly commodity it set up, in the year 1880 alone, 168,056, which is about two thirds of all the poles erected that year.

The magnitude of these figures is by no means wholly due to the extension of lines in newly developed portions of the country. The growth has taken place in cities as well. In New York city, for instance, there are now twenty-five public telegraph and four telephone companies, to say nothing of electric-light organizations and private

parties using wires. Their operations are conducted in two hundred and eighty-five offices, allowing only one office to each telephone company. But, as each telephonic subscriber requires a separate instrument, there are, practically, as many offices as subscribers, and the above number must be increased by several thousands. As each of these thousands of telegraphic and telephonic offices has from one to several hundred wires running from it to some other point, one realizes what a gigantic net-work of wires has been woven over us; and, when we add the testimony of the senses, the stupendousness of the encroachment becomes still more apparent. From roofs of private buildings and from poles in public streets the meshes depend, each pole strung with from to one to one hundred and sixty or even more wires. At the corner of Wall and Water Streets, for instance, is a pole with one hundred and ninety-six insulating points. Be these public ways wide or narrow matters not, so far as encroachment is concerned. Some of the largest poles have been erected in the narrowest ways. In Fulton Street, west of Broadway, for example, there are poles seventy-eight inches in circumference. In other places poles sixty and sixty-four inches in circumference have been placed, and a diameter of a foot and a half is common.

Now, all these facts and figures bear startling testimony to the extent to which a system of encroachment upon public and private rights may silently proceed when unchecked. When to this thought we add a recollection of the instances of danger, obstruction, and accident occasioned to life, limb, and property by wires and poles, it must be admitted that a system, whose benefits can hardly be overestimated, has nevertheless become, through an utter disregard of the changed conditions brought about by time, obnoxious in its operation. In the language of modern thought, it has failed to adjust itself to its changed external relations. It is out of correspondence with its environment. This want of correspondence in the case of a human being is called death. In the case of the system under discussion, instinct has taught the layman to call it a public nuisance, which, if so, is theoretically about the same thing as death, inasmuch as, in the eye of the law, that which is a public nuisance has forfeited the right to exist. That this lay opinion is right and that the system is, *per se*, a public nuisance, is a matter of elementary law.

How comes it, then, that such a condition of things has arisen? Ask the offending corporations, and they will tell you that it is a *legalized* nuisance, and point to legislative enactments which they claim legalize their acts. It becomes necessary, then, to examine these enactments. In a magazine article it is of course impossible to review the laws of all the States. We propose to confine ourselves, therefore, to those affecting New York city, which is the longest-suffering and most interested of our municipalities.

The Legislature of the State of New York, in 1848, authorized the

incorporation of companies for the purpose of constructing a line of wires of telegraph through the State, from and to any point within it. This was the franchise, and it was given upon certain terms, conditions, and liabilities. Lines of telegraph might be constructed along and upon any of the public roads and highways, or across any of the waters within the limits of the State, by the erection of the *necessary* fixtures, including posts, piers, or abutments for sustaining the cords or wires of such lines, *provided* the same were not constructed so as to incommode the public use of the roads or highways or injuriously interrupt the navigation of the waters. By a subsequent act, in 1853, it was provided that any number of persons might associate for the purpose of owning or constructing, using and maintaining a line or lines of electric telegraph, whether wholly within or partly beyond the limits of the State, or for the purpose of owning any interest in such line or lines of electric telegraph or any grants therefor, upon such terms and conditions and subject to such liabilities as were prescribed in the act of 1848. Such association was authorized to erect and construct from time to time the *necessary* fixtures for such lines of telegraph, upon, over, or under any of the public roads, streets, and highways, and through, across, or under any of the waters within the limits of the State, subject to the restrictions contained in the act of 1848.

It is under these acts that the evil we complain of has principally arisen. With regard to the exceptions, as, for instance, the electric-light companies, although the language of the statutes authorizing their creation is in some respects different, the principles laid down in this article are, in the main, so far applicable that the same general conclusions are deducible. For the same reason, therefore, that led us to avoid a general review of all the State laws, no separate discussion on this point will be instituted.

It will be observed that, in the legislative acts cited, unqualified power as to the methods of exercising the franchise is not given. The companies are, in effect, prohibited from erecting any fixtures except those which are necessary, and, whether necessary or not, the land-fixtures must not incommode the public use of the streets. Any unnecessary or incommoding fixtures still remain an unlegalized public nuisance. Are, then, the wires and posts necessary, as at present erected? Do they incommode the public use of the streets?

Take the latter question first. When a street is laid out and opened, all persons acquire the right to use it, to pass and repass at their pleasure *on any part* and in such direction as may suit individual convenience and taste.* This is what is meant by the public use of a street. Now, the right of the public to use the public streets freely and in every part can not well be exercised when poles occupy a portion of the land. If what is called "the fourth dimension of matter" were a reality, a person might be able to pass through the pole without disadvan-

* Allen's "Telegraph Cases," p. 139.

tage to himself or the pole, but "the fourth dimension" is not as yet a demonstrated fact, and without it the space occupied by the poles is withdrawn from the public use. The fact that sufficient space remains for public traffic is immaterial.* The public use of the streets is therefore disturbed and inconvenienced, or, in other words, *is* incommoded. This, unfortunately, is not the full extent of the disturbance. To illustrate:

That man should be protected in the enjoyment of life, limb, and property is recognized in every system of law. That the fire department is a potent instrument in such protection goes without saying. That its occupancy of the streets, with its paraphernalia of safety and protection, is a proper public use of the streets, none will gainsay; and that the fullest facilities should be afforded it for the untrammeled exercise of its protective powers is self-evident. Now, a New York city fire-department official recently stated that the firemen are delayed at almost every fire in raising ladders by the wires which are strung in front of the houses. He considers them a very serious obstruction, and adds that if there were no telegraph-wires strung through the streets the fire department could raise a much longer ladder than they do at present. Serious difficulty, he continued, is met with in fighting fires from the outside of buildings, on account of the wires, which make a net-work in front so strong that it is impossible to force the water through it. Poles, too, are in some instances placed so close to hydrants as to interfere with the firemen's work. This being so, how can it be denied that the public use—and a very important public use—of the streets is seriously interfered with and incommoded? Must it not, then, be admitted that, measured by one of the tests of legality, the overground system falls short of the requirements necessary to bring it within the pale of protective legislation, and must still be adjudged an unlegalized public nuisance?

How does it stand the other test prescribed by the Legislature? Are poles and over-ground wires *necessary* fixtures in cities? The companies contend that the statutes expressly authorize the erection of posts and wires. Is this so? The act of 1848 (which, if not supplanted by the act of 1853, is the only one which refers to posts) authorized the erection of the *necessary* fixtures, including posts, piers, or abutments. The only permission given is to erect such fixtures, including posts, piers, or abutments, as are necessary. Only by doing violence to the English language can the words be interpreted otherwise. The construction placed upon them by the companies, followed out, leads to an absurdity. If, as they claim, there is unlimited authority to erect poles in the streets whether necessary or not, there is exactly the same authority to erect, *in the streets*, piers and abutments. But it is plain that such erections were never intended to be made in the streets, and no company would claim it. The fallacy lies in confound-

* Allen's "Telegraph Cases," p. 180.

ing the franchise, which is to construct lines, with the method of its exercise. The two are distinct. The former is absolute; the latter is conditioned. None can dispute the right to construct lines, but *how* it shall be done depends upon what is necessary. Piers and abutments may be necessary in certain places, and posts in others. When necessary they may become lawful; but neither piers, abutments, nor posts are lawful erections where they are unnecessary. This is a fair construction of the language used.

Are posts, then, necessary to the enjoyment of the franchise of the telegraphic companies in cities? That depends upon whether there is any other practicable way of exercising the franchise which is less of a nuisance, for the franchise must be exercised, in crowded cities, at least, in such manner as to obviate the nuisance, if possible, and inflict the least injury upon others, the best means to that end being employed, and, if there are two ways in which a franchise can be exercised, one of which would create a nuisance and the other would not, or would at least diminish it, that method must be adopted which will obviate the nuisance, or reduce it to a minimum. Otherwise, the act becomes unlawful for exceeding the limits within which obstructions are allowed in the interests of the public.*

Now, it is well known that there is, besides the overground system, an underground method of constructing lines. The latter, manifestly, does not permanently obstruct the streets, or incommode the public use of them. In fact, the courts have decided that it is not in fact or in law a nuisance.† Moreover, under this system, the exercise of the franchise is very unlikely to result in injury to person or property. If this system is practicable, the telegraphic companies must, in view of the principles applicable to their case, adopt that method. For, if the pole system is a nuisance, and the underground way is not; or, if the former permanently obstructs the streets, and the latter does not; or, if the pole system is dangerous to life, limb, and property, and the underground plan is not, or is less so—then, so long as the poles are left standing, and the wires strung, the franchise is not exercised in such manner as to reduce the nuisance to a minimum, and to inflict the least injury upon others, and the corporate acts are unprotected by law.

The question of necessity resolves itself, then, into a question of the practicability of the underground system. There are many who claim it to be impracticable, and, as a matter of course, there are imperfections in the system, in which respect the overground method is like it. But to all that may be said against it, there is one indisputable reply, that subterranean wires are serving their purposes successfully in various parts of the world to-day. The system is successful in London; also in Paris, and other European cities. Miles of wire have been successfully operated in Washington. An underground system has been tried with success in Philadelphia. It has worked well in

* § 60, N. Y., 510. † Allen's "Telegraph Cases," p. 173.

other cities; and, finally, *for its own convenience*, the Western Union Company has several miles of wire underground in New York city, which are also operated successfully. When to these undisputed facts we add that such a practical genius as Edison has declared that *there is no reason whatever why all wires operating electrical apparatus should not be underground*, except expense, which in the eye of the law is no excuse, there is sufficient demonstration of the practicability of the system for the purposes of this article. Unless such evidence can be rebutted, the companies are guilty of erecting, in the exercise of their franchise, unnecessary and therefore unlawful fixtures.

If unlawful, within the meaning of the legislative enactments, no aldermanic sanction can save them; for the stream can not rise higher than its source. Permission by the Common Council, if inconsistent with the law of the State, is wholly void, and, even if this were not the case, it is questionable whether the Common Council of the city has power to consent to the erection of a single pole. The charter gives it power to regulate the use of poles in streets, but the power to regulate a nuisance is not the power to create one. This becomes more apparent taken in connection with the prohibitive side of the charter, by which the Common Council is forbidden to permit *any* encroachment upon or obstruction of the streets, except the temporary occupation thereof during the erection or repair of a building on a lot opposite the same. Now, this either means something or nothing, and, with the principles in regard to legalizing nuisances in mind, we are inclined to believe it means all that we claim.

Before leaving this point, it may be added that, even if there were no such thing as an underground system, it is quite probable that most of the poles now standing would have to be condemned as nuisances; for, if smaller poles of the same or another material, such as iron, would answer the same purpose, the obstruction as it now exists is not reduced to a minimum, and, under the principles of which we have spoken, are therefore unlawful. That smaller poles would do, is, we think, capable of demonstration, but it is not necessary to enter upon a discussion of this matter, as our objections are aimed at the overground system as a whole.

To the reasons we have thus far given why the poles and wires should come down, there may be added another reason. Recent elevated-railway litigation has made the public more or less familiar with certain principles of law regarding the use of streets by private corporations. Whether the fee of a street is owned by the abutting owners, or has been taken by the public, but in trust to be used as a public street, no structure upon the street can be authorized that is inconsistent with the continued use of the same as an *open* public street, without compensation to the abutting owners, who are entitled to use it.* Measured by this principle, there is no difference between an elevated-

* 90 N. Y., 122; 91 N. Y., 153.

railway structure and a telegraph-pole. Both are uses of the street inconsistent with the use of the same as an open public street. Such use in both cases violates the rights of abutting owners to freely use or pass over the street. How, then, has a single post been legally erected, if the owner of the premises, whose rights are violated by the erections in front of his property, has not *first* received compensation, be it ever so little, awarded him in due form? It is safe to assume that not one cent has ever been paid by way of such compensation, and, that being the case, such structures must fall under the prohibition of the above principle, and are therefore unlawful.

But, if, after all, none of the foregoing objections are tenable, is there no way of getting rid of the evil? If a panacea does not already exist, one suggests itself in legislation. Our State Legislature can relieve us. It has the power to drive the poles and wires from the street, and compel the construction of lines underground. As to wires yet unstrung and poles yet unerected, it may be said this course would be quite proper, but with regard to those already up (assuming that they are legally up) would not such legislation be manifestly unconstitutional, as impairing the obligation of the charter contract which, we will say, authorized their erection?

Now, the framers of the Constitution, in declaring against the enactment of laws impairing the obligations of contracts, never intended that the Legislature should altogether avoid retrospective action upon the civil relations of parties to existing contracts. No Legislature ever did avoid it, they said, and to require it would be extremely inconvenient.* It has accordingly frequently been held by our courts that the clause in question does not so far remove from State control the rights and properties which depend for their existence or enforcement upon contracts as to relieve them from the operation of such general regulations for the good government of the State and the protection of the rights of individuals as may be deemed important.† All enactments are subject to the subsequent exercise by the Legislature of what is known as the police power, which the Legislature can not alienate, if it would, but must reserve to itself in order to avoid embarrassment in the exercise of control over the general welfare. By virtue of this power the Legislature may, for the public welfare, subject persons and property to various restraints and burdens. It may abate nuisances, even if in their origin they may have been permitted or licensed by law. It would be monstrous if it were otherwise. If a charter implies that a corporation may always continue to exercise its rights in the same way in which their exercise was at first permissible, and under the regulations then existing and those only, the public would be helpless when, without anybody's fault, circumstances so change that what was once lawful, proper, and unobjectionable, be-

* Cooley's "Constitutional Limitations," p. 716.

† Curtis's "History," vol. ii, p. 367.

comes a public nuisance, endangering the public health or the public safety. As circumstances change, regulations affecting the exercise of a franchise may be changed, too. "It can not be," said the Court in one case, "that the mere form of the grant should prevent the use to which it is limited being regarded and treated as a nuisance *when it becomes so* in fact."* In that case, as in many others, the exercise of the police power was held constitutional, even though it directly violated rights theretofore given. By this power the removal of mill-dams once lawfully erected has been compelled, and railroads have been obliged to adopt devices for safety not prescribed in their original charters, even though it caused expense. That is not a matter to be considered when a question of public safety is concerned. Then why should this power not be resorted to in the case of telegraphic and electrical obstructions? Are they exceptions to the rule that when under changed circumstances lawful erections become nuisances they may be abated? We think not. The police power ought to be exercised. Legislation, by virtue of it, driving the wires underground and the poles from sight, would, we submit, be in every respect constitutional and proper.

Such legislation might take the form of direct enactments against the evil, or of a delegation of authority to act in the matter to municipalities. While the police power can not be alienated, it may be delegated to a municipality; for one of the objects of the creation of municipalities is to exercise certain powers of the State in localities. In New York city, it may be that, in the right to regulate the use of streets for poles, the local legislative body has been already clothed with this power sufficiently to meet the evil. Be that as it may, the point remains the same, that the evil is to be met by legislation. Whether by the principal directly, or indirectly by its agent, matters not, so far as its propriety or constitutionality is concerned.

If we are right in our conclusions in this article, why should the evil be allowed longer to exist? Is the corporate power greater than the influence of public opinion? Or, if so, shall public opinion be left unsupported by concerted action? As in politics, or almost any other sphere of action where many are concerned, so, in the suppression of this evil, much depends upon the part taken and the activity displayed by the individual. Those who put forth no exertion to save their rights and tranquilly sleep on them need not be surprised if their rights are trampled upon.

* Cowen (N. Y.), 605.

STETHOSCOPY.

By SAMUEL HART, M.D.

ONE fifth of the adult population of Christendom is suffering from chest or thoracic diseases of a degree varying from the insignificant to the most grave; while another fifth is living in constant fear of being or becoming their victims.

In fact, diseases of the lungs and heart far exceed those of any other class in prevalence and fatality—consumption, so called, causing one fourth of the mortality between the ages of seventeen and thirty-five years—while diseases of the heart are of well-known formidable character, and raise the proportion of thoracic or pectoral diseases to a surprising ratio.

The study of this subject, as regards the causes and preventives, the symptoms and cure, has received the diligent attention of scientists and sanitarians as well as of physicians.

Leaving to the physician his subject in its multiple and exhaustless forms, I propose in this paper to give some account of the practical diagnosis, or methods of determining the nature, exact locality, and extent of thoracic disease, by means of stethoscopy, or the physical exploration of the chest.

The thorax incloses the essentially vital organs—the lungs with their pleuræ, or delicate membranous coverings, and the heart with its pericardium and great blood-vessels. These, actuated through their system of nerve-filaments, give the rhythmic heavings of respiration and the throb and pulses of the blood-circulation.

Although so admirably guarded against harm by the strong and elastic chest-walls, and against all inimical approach by that ever-vigilant sentinel, the epiglottis, they are, from the very nature of their functions, pre-eminently subject to danger from without as well as from within. The delicate mechanism of living lung-tissue can not be subjected to direct observation; the minute cells for containing air would be crushed by air admitted from without, and the heart arrested for a moment for inspection would never beat again; yet the vital operations of these organs are well understood and their morbid conditions can be read almost as if exposed to view.

On firmly applying the ear to the walls of the chest of a person in health, certain sounds can be heard, varying in loudness and clearness with the quarter of the chest at which the ear is applied, and with the age or individual peculiarity of the person examined, or his state of action or repose. The double sound of the heart, embracing what are known as the first and second sounds, is heard distinctly: the former caused by the strong muscular contractions of the ventricles, mainly the left, whose function it is to distribute the blood to the system.

This contraction causes the pulse, with its many qualities of quick or slow, soft or hard, regular or intermittent, and others which furnish to the *tactus eruditus* valuable indications of the physical condition not only of the heart itself, but also of the system at large.

The sounds of respiration are also heard: the inflation of healthy air-cells, producing the *vesicular murmur*, is audible even to the unaided ear.

This direct application of the ear to the chest (called *immediate auscultation*) is preferred by some as having advantages over the *mediate* or instrumental method. The former is, however, open to some objections which are readily apparent, both as regards the subject and the examiner; while the stethoscopic method possesses numerous advantages, without the objections.

The following is a brief description of the appliances ordinarily in use in exploring the thoracic contents:

First in importance among these is the *stethoscope* (Fig. 1). This instrument, in its primitive form, was exceedingly simple: at first a cylinder of paper, rolled tightly and of convenient length. A ready substitute was found in wood; and this was carved or turned to give lightness and to improve appearance. Cedar and ebony have been preferred, as being of fine quality and easily polished. Vulcanite and

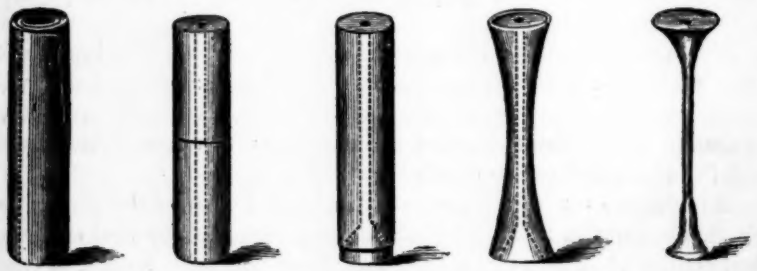

Fig. 1.

various metals are also used, made in similar form—i. e., a tube of suitable length, expanded at one end into a hollow cone for application to the chest, and suited at the other end to the rim or opening of the ear. In these as in all other forms the object is to insure, when in use, a confined column of air extending from the bare walls of the chest of the person examined to the ear of the listener; and upon the completeness of the adjustment and consequent inclosure of the air depends the efficiency of the instrument, since the confined air—not the instrument—is the medium of conduction of the sounds.

The *flexible tube* was used later as a step in stethoscopic evolution, which gives the advantage of allowing comfortable respiration without disturbing the inclosed air of the tube by the movements of breathing, which tend to press the instrument alternately against the ear of the listener (Fig. 2).

The *binaural stethoscope* (Fig. 3) of Dr. Camman, of New York city, is unquestionably the best instrument known. Its name signifies its peculiar advantages. Two tubes (one for each ear), suitably curved,

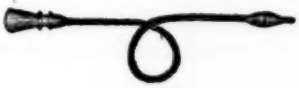

Fig. 2.

and each furnished with a rounded bulb for accurate fitting to the opening of the ear, are connected at the other ends with a hollow cone for application to the chest of the person examined. The cones or chest-pieces are of various sizes, and are adjusted and used interchangeably according to the required extent of field which has its limits between one and two inches in diameter. They are made from ebonized wood, vulcanite, or soft rubber, the latter being required to

Fig. 3.

prevent painful pressure on uneven surfaces of the chest. In a part of their course the tubes are elastic, the remainder being metallic. They are so constructed as to be easily and perfectly adjustable to the ears by softly elastic springs. By this arrangement both ears are not only equally engaged with the same sounds, but other sounds are practically excluded. This feature is fairly represented in the binocular microscope and in the stereoscope, which possess the full advantages derived from the use of both eyes. Thus the stethoscope heightens and places in relief our auditory perception of the movements and conditions of deep-seated vital organs, giving prominence to the lines and shades of a picture otherwise flat and indistinct. It will, of course, conduct all sounds communicated to it from without, thus making it necessary to avoid all frictional contact with the instrument, even of the lightest clothing; and the listener will steady it deftly by thumb and finger to escape confusion from a multiplicity of sounds. By the practiced ear, however, most of the numerous adventitious sounds can readily be eliminated and the attention successfully fixed on the one sought.

The means next in importance in questioning the condition within the thoracic cavity is *percussion*. It consists in striking upon the chest with carefully-suited force with the tips of one or more of the

fingers slightly bent; or with a light elastic hammer called the *percussor* (Fig. 4). The finger of the other hand or a solid, flattened disk, the *pleximeter*, must be held firmly against the chest to receive the stroke and to educe the proper resonance. The percussion-sound, though apparently unmusical, must have its intensity, be high or low, and have its peculiar *timbre*—all requiring acuteness of hearing and judgment in interpretation.

The *spirometer* is of use for measuring in cubic inches the maxi-

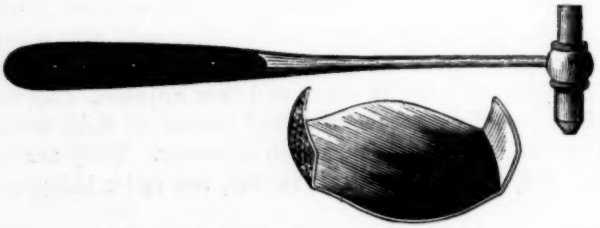

FIG. 4.—FLINT'S PERCUSSOR AND PLEXIMETER.

mum amount of respirable air, of which each individual has his normal quantity, but which is subject to changes from organic affections of the lungs.

The *cyrtometer* is used for delineating the external contour of the chest and for exact comparison of one side with the other.

Numerous other instruments are of real utility, only one of which, however, will be mentioned.

The *sphygmograph* is an instrument of somewhat complicated mechanism. It is used to "feel the pulse" and to record its impressions. It will give its frequency and rhythm, its varying tension and strength, the condition of the heart and certain valves, with a delicacy and exactitude which, compared with the results obtainable by the most sensitive finger, are like the perfect work of photography compared with the attempts of the juvenile charcoal artist. With its touch upon the heart or its vessels, and its pen apparently in sympathy and vital connection with them it will record in delicate but infallible tracery the diagnosis, and mayhap the prognosis, of the subject under examination, which may be read with trembling expectation.

In this instrument the impulse of the blood-movements is communicated to the pen by water contained in flexible tubes. The oblong receptacle, also containing water, is connected with one of these tubes. It has on one side an elastic projection which is to be securely fixed upon the pulse to be examined. All vibrations received by it are transmitted by the water through the tube to the chamber. On the upper surface of the chamber is a delicate membrane which receives the vibrations with every requisite as to quality and exactitude. The movement of its wave is, however, microscopic, and, in order to render it visible and legible, an exceedingly light and sensitive lever termi-

nating in a pen is so placed in contact with the membrane as to amplify manifold in tracings the movement it receives. The inscription is received on a slip of smoked glass, which is made to move before the pen with precision by a mechanism which also acts as the chronograph, indicating the time at the lower edge of the glass in seconds and

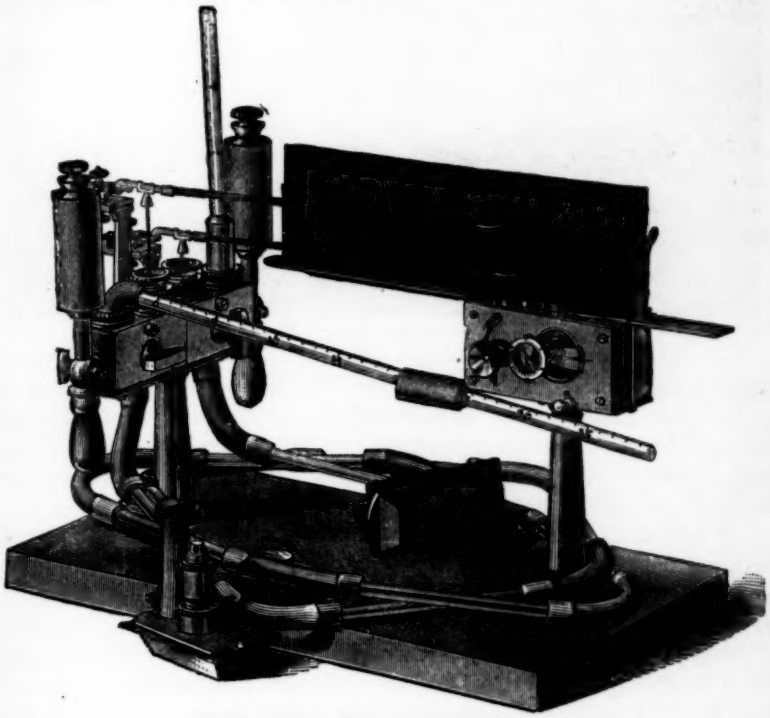

FIG. 5.—KEYT'S COMPOUND SPHYGMOGRAPH.

fifths. A second pen with similar connection is made to trace on the same slide the movement of another pulse at a distant part of the system.

Space will not permit of reference to the numerous and important accessory contrivances of the complete instrument, nor to the numerous indicatory marks on the following cuts. To the specialist they are significant and essential. Simultaneous tracings of the heart and a large blood-vessel of the neck are shown below (Fig. 6). It should be explained that the upward stroke in the tracing answers to the heart-beat; the downward stroke and succeeding wavelets indicate the recoil of the blood and the tension of the vessels; while the whole cycle with its chronometric line below furnishes a wonderful map.

This graphic method includes cardiography, in which a tracing is obtained of the pulsations of the heart, and pneumography, in which are recorded the movements of respiration. It includes also the mul-

tiple simultaneous method, in which two or more vital movements—for instance, of the heart, pulse, and respiration—are recorded at the same time, showing their exact relations to each other. The sphygmograph, in the compound form of Dr. Keyt (Fig. 5), with a chrono-

FIG. 6.

graphic attachment, is a modern mechanical help in stethoscopy of great value, and has given important light on questions of physiology and pathology. It is an instrument of precision, of scientific interest and importance, and in difficult physical explorations the graphic method is found almost indispensable.

A few cases will now be given illustrative of practice in stethoscopy. A patient has the following symptoms: "Shortness of breath, smotherings, cough with little expectoration, pain of the side, varying from the sharp stitch to the dull and aching pain." The illness and distress are evident, and though the question of present relief is uppermost in the patient's mind, he has sufficient intelligence to demand and to comprehend the *cause*. From the symptoms given it may with about equally reasonable grounds be supposed that the trouble depends upon organic changes of the heart, its valves, or its pericardium; of the lungs or their pleuræ; or upon disturbances not directly connected with these organs at all, but arising from impressions transmitted through the reflex system of nerves; or it may be owing to a combination of two or more of these causes.

No amount of experience or tact will enable the physician to do more than to guess the diagnosis from these symptoms. He is unable to prescribe intelligently the needed means of relief and of the expected cure except by means of physical exploration of the chest. On inspection, increased frequency of breathing is observed: this is a suggestion only.

On applying the stethoscope the heart is found somewhat displaced, but perfectly healthy as regards its size, its valves, its membranous coverings—an important step by way of exclusion of certain possible conditions.

The whole of the left lung is found performing its functions healthfully. Nor is any disease found in the upper portion of the right lung; but, on searching the lower two thirds of this side, there is found an entire absence of all sounds of respiration; and, under percussion, no normal resonance due to the presence of spongy lung-tissue is heard—the sound is *non-resonant.* A partial resonance would be *dullness;* in this case it is "*flat.*"

These data prove the absence of all healthy lung-tissue in the lower two thirds of the right side of the chest. What, then, occupies this region? The lung solidified by morbid changes may be there; or it may be displaced by a tumor, or by fluids; and each of these morbid conditions has nearly the indications mentioned. On carefully examining the upper limit of flatness of sound, while the patient is sitting or standing, it is found to extend exactly horizontally around the chest. Next, requiring the patient to recline backward, the physician finds the boundary-line of flatness to have changed to two or three inches lower on the front, while upon the back of the chest it will be higher than before; yet the line is still strictly horizontal.

The significance of this test is that, though the chest has changed its position, its movable contents, obeying their physical law, tend to preserve a horizontal surface.

Certain complications may prevent the availability of this "hydrostatic test"; but when found it is infallible, and in this case excludes all of the supposed conditions.

The diagnosis now is, that the right lung has been compressed into a narrow compass in the upper part of the chest by the gradual accumulation of from thirty to forty ounces of fluid; and this fluid has also so encroached upon the heart as to cause some displacement and to embarrass its action as well as that of the left lung. These conditions account fully for the symptoms mentioned, and for the distress of the patient.

Negatives, exclusions, and probabilities alone are inadmissible; a *diagnosis* is required. The examiner may not *guess* from the symptoms; his tests must be objective, and as positive as the laws of physics. They must not fail, for the life of his patient is at stake; and the treatment to follow will prove his skill, or, may be, his fatal error. If a small hollow needle be pressed through the chest-walls into the suspected region, the outpouring fluid will bring the needed relief and will verify the predictions of the ear by actual sight, weight, and measurement. This case is one of no uncommon occurrence, the treatment almost painless, and very satisfactory as to present relief and the prospect of permanent cure; the lung may expand to its normal size, and resume its functions healthfully. And the case is one requiring only the ordinary and easier means of diagnosis.

The acutest ear and the most practiced discernment are required in meeting the difficulties arising from complications of diseases, and

the absence of those sounds and changes which are sufficiently distinct and characteristic—a condition to be expected in all earlier stages of pectoral troubles.

A life-insurance agent brings to his company's medical examiner an individual whom he considers an exceptionally "good risk." He has the facial appearance, the physique, and record of perfect health. The examiner, in making up the rigid descriptive list for his company, must assure them, as "parties of the first part," that in this case the sounds of the heart are perfectly natural; that its movements are entirely correct as regards their rhythm, strength, and frequency; that the pulse does *not* intermit, etc.; and that there is no disease or morbid condition, or tendency thereto. Tested by the spirometer, the applicant is found to breathe easily the amount of air known to be the average for persons of his size (more strictly, height). By the usual tests of auscultation nothing is found wrong. On a more scrutinizing review of the case, as becomes the faithful officer who is to be the impartial judge on the trial, a small area is found near the upper portion of one lung where, by percussion, the normal resonance has given place to a degree of dullness—a sound which signifies the half-way limit between the resonance of perfect health and the "flatness" of advanced change.

This quality of sound would pass unobserved, except for easy comparison with the adjacent portion of the same lung, and with the corresponding part of the opposite one. The dullness is found to be better shown by light percussion than by more forcible strokes—an indication of the superficial situation of the changed tissue.

On again applying the stethoscope over the region, the natural vesicular quality of the inspiratory murmur is found to be changed to the broncho-vesicular murmur—indicating partial solidification of lung, which, if more complete, would give the bronchial or tubular sound. The pitch of its tone is raised, and it is "rough" or "harsh." A sound of *expiration* is also heard *distinctly*, while normally it is barely audible.

There are now three facts which tend to becloud the otherwise good record of the case.

A further test may be made by auscultation of the applicant's voice. On applying the stethoscope upon the place mentioned, the subject is required to speak or count in his ordinary tone of voice. There will be heard sounds apparently near the ear, approaching in distinctness to words—not articulate, as would be heard in complete solidification, but easily distinguished from the distant jarring sound of a healthy lung, called vocal fremitus.

The applicant has now through his own honest voice given adverse testimony. Try next whether he shall *whisper* a confirmation of the same unfavorable story. The whispering voice heard through solidified lung-tissue is increased in intensity and raised in pitch,

which, discouraging symptoms being found in this case, may suffice although further tests are available.

There are now five witnesses, each of whose testimony is more than "circumstantial"; collectively they agree perfectly and are invariably truthful.

The following decision must be rendered: The applicant is in possession of health so good, and a record so favorable, that he has probably made his application for life-insurance in all fairness, but, subjected to the company's exact tests, he is debarred. He must be rejected on the ground of organic pulmonary lesion. A portion of one of his lungs is by some morbid process changed from its delicate, spongy structure to one which is more solid; the air-vesicles have been encroached upon by material which not only has interfered with their functions (though inappreciably to himself), but which may prove a progressive and fatal invasion.

This case is one of a numerous and highly important class—an individual in fair health, without symptoms of any disease, is, by the stethoscopic ordeal, accounted a "bad risk," or is denied the advantages of assurance, and informed that some hygienic or curative course is essential for his safety.

On the other hand it may be stated that, without multiplying illustrations, there are very numerous instances in which the subjective indications (symptoms) of organic disease are so prominent and the distress so urgent as to appear conclusive proof of imminent danger. A test of a few moments' time will make the correct diagnosis and furnish a comforting stethoscopic negative.

Disorders of the heart, although of less frequent occurrence than those of the lungs, are of equal importance and require the best skill of the examiner.

In searching for its disordered conditions it is necessary to keep in mind the anatomical features of the organ. As a piece of mechanism it is a pump, constructed of pliant, fleshy walls; it has four chambers with numerous valves, and its columnæ and chordæ. Protected from friction and abrasion by the constantly renewed fluid within its strong membranous incasement, it expends an incredible amount of force in its incessant and exclusive work of propelling the blood. But it must also be considered as a *sensitive center* with an apparently independent vitality, in direct communication, through its web-work of nerves of the sympathetic system, with every organ and tissue of the body, according to whose demands, as well as to the varying activities of the brain, it regulates its movements.

The manner of this response is frequently so energetic and tumultuous as to cause much mental disquietude, if not real physical distress, and to furnish the well-known question, whether there be "functional or organic disease."

Its vigorous impulsion, its notable sounds, and its location near the

chest-walls, render a study of the condition of the heart entirely practicable by stethoscopic auscultation. By this method its size, its location, and the state of each of its valves can be learned with much precision.

The heart-sounds are sufficiently loud and distinct to be susceptible of much exactitude of description and characterization. The contraction of the ventricles, which mainly produces the "first sound," is the exertion of a force equal to the grasp of a strong hand; it is forcible and quick, but its time as represented by its sound is measurable. This sound is composed of two elements—one of propulsion, with a "booming" quality which is the characteristic, and one of valvular, or sudden clicking sound. Its rhythm, as observed in its succession, is trochaic.

The "second sound" is principally caused by the sudden arrest by the semi-lunar valves, of the column of blood in its tendency to return to the heart under the elastic recoil of the arteries after their forcible distention. It is quick and valvular; it is higher in pitch than the first sound and its rhythm is iambic.

Each of these sounds is more or less ringing and clear and has its appropriate *timbre*.

After an almost imperceptible interval, the "first sound" is followed by the "second," then by a rest; the whole cycle occupying about one second of time. Its divisions may be represented as follows: first sound, $\frac{4}{10}$; second sound, $\frac{3}{10}$; rest, $\frac{3}{10}$. Each has its exact normal place of greatest intensity and perfection, relative to the external topography of the chest, and variations from this rule will be an index of change of structure within the heart itself, or of displacement from malformations or morbid conditions of the adjacent organs.

It is convenient to designate as *heart-sounds* those sounds which are normal, and as *heart-murmurs* those sounds which are adventitious and, as a rule, indicative of organic changes.

The murmurs are of peculiar character, of great variety, and usually of important significance. They originate either within the heart (endocardial) from defective valves or obstructed orifices, or else without it (exocardial) from friction against morbid accumulations within its membranous envelope; or, finally, though exceptionally, they are found to depend upon certain conditions of the blood.

The murmurs are very numerous and variable, and difficult of description according to any rules of rhythmics, melodics, or dynamics; as will be seen from the following names applied to them—and these only a fraction of the whole list: sawing, rasping, scratching, scraping, grinding, creaking, rubbing, churning, blowing, whistling, cooing, purring. And, as if from poverty of language, fashion or necessity has led to borrowing from abroad; as *frémissement cataire, bruit de souffle, bruit de scie*, etc. The terms in use should through some conventionality be revised. Many of them, however, are practicably indispensa-

ble and fairly expressive of sounds actually and distinctly heard, for which a verbal rendering is necessary.

The loudness and clearness of the murmurs are by no means proportionally indicative of their gravity; since one barely audible may from its location and character be a low premonition of mischief, while a more demonstrative one may have no important significance.

In a rare case, a musical murmur was heard exactly resembling the notes of the cuckoo; it was so loud as not to be the exclusive property of stethoscopists, for it could be heard at a distance of several feet. Moreover, it was shown by the "demonstrator," *post longam vitam*, that the heart whence the sound had proceeded was entirely free from all organic disease.

The mechanism concerned and the method of determining the kind and location of a murmur may be referred to very briefly.

As an example, organic disorder of the aortic semilunar valve will be presumed. Imperfections of this valve are among the more frequent diseases of circulation, and are of import more or less serious according to their extent; its total failure nullifies every anatomical perfection in all the other organs of circulation.

With the stethoscope suitably placed, a distinctly audible murmur will be detected. On observing the rhythmic succession of "first" and "second" sounds the murmur will be found to occur exactly with or in place of the latter, whose sudden click will at least be notably weakened. The murmur is found over the position of the semi-lunar valve and extending downward in a line toward the middle of the chest; it is slightly prolonged after the "second sound." No other murmurs are discovered. These are sufficient data for a diagnosis.

The observer has seen, as it were, two ounces of blood destined for the wants of the system driven through the semilunar gateway into the great vessels; this movement was accompanied by the normal booming "first sound" and was attended by no murmur. There was, then, no obstruction or narrowing of the orifice, nor roughness of the valve, that by consequent vibrations could produce a murmur. But the observer has seen the measure of blood, under the elastic pressure of the vessels, returned upon the semilunar valve for momentary support, where, instead of being promptly arrested by the three-winged leaflets, a portion passed between their narrowed or irregular edges into the heart, and at this instant of regurgitation the murmur was heard. The blood could flow unobstructedly from the heart, but its unfavorable retroversion was made possible by the organic imperfection called *insufficiency* of the semilunar valve of the aorta.

The sphygmograph alone would have written the above diagnosis in this uncomplicated case with entire completeness, and its tracings would have shown also, as a part of the pathological history, that the valvular defect originated many months ago; that, through the natural curative processes the heart had gradually increased in strength

until full compensation for the defect had been reached; and that, with the growth of strength there had been corresponding enlargement, which, instead of being a morbid condition, however, is in this instance really conservative and favorable.

While stethoscopy possesses an interest amounting to fascination, from its vital importance, from the numerous difficulties which can be overcome by reasonable diligence, and from the great degree of exactitude on the whole attainable, it still has its difficulties intrinsic and its difficulties of circumstance. In its practice observations must be made principally through the single sense of hearing; for, practically, the organs which are within the range of a whisper are to the other senses as distant as the antipodes.

There are difficulties from within the chest, from overpowering abnormal sounds, as in the asthmatic subject, where the noisy "râles" entirely predominate, rendering auscultation of the heart temporarily impracticable.

Obscurities and difficulties arise in a negative way from lack of expression; occasionally, all sounds are distant and confused, responses are slow and ambiguous, and the observer is made to feel the need of a perfected microphone which shall amplify, localize, measure, and, in fine, characterize all obscure indications.

Difficulties from circumstances arise from disturbing voices or footsteps, or the roar and rattle of busy streets, and innumerable other sounds which may in part preoccupy the ear with their clangor. There are difficulties from disinclination on the part of the individual examined to offer the requisite time and facilities. There is too often incompetence on the part of the examiner; his sense of hearing as an auscultator may be defective, though not appreciable by any other test. He may never have acquired the requisite degree of skill gained only by persevering practice, commencing with the normal conditions in healthy persons, thence through every class and grade of morbid states, until he has become the trustworthy adept, if not the technical expert.

Difficulties exist to prevent the full popular benefit from stethoscopy, arising from the want of a better general knowledge of its claims and capabilities. Formerly, when the circulation of the blood and the functions of respiration were unknown and the arteries were supposed to be air-vessels, the *materia medica* was a wonderful list with which the physician made his round of experiments. In those days, in case of a mysterious death, the verdict of the coroner's court would be, "Died by the hand of God," and was considered as duly explicit.

Sufficient advancement has now been made not only to demonstrate the physiology of the lungs, heart, and arteries, but to comprehend every shade of their diseased conditions and to show that the larger part of the remedies once in use were entirely inapplicable; and the coroner, with no irreverent intent, but under the fear of the charge of

ignorance, must now demonstrate the physical means and the exact locality of the fatal impress—perhaps found as a heart-obstruction, or a minute embolus deep in the labyrinth of the brain, to which some physiological clew may have led.

Aside from the inherent obscurity and difficulty connected with the subject of medicine, there remains as a heritage of by-gone ages an unwonted mystery associated with it, which should be more rapidly dispelled; and while the profession is making good progress in elaborating and writing its more exact laws, it is the duty of the intelligent laity to free themselves from the vestiges of mysticism, and seize upon the more prominent and available facts and principles which are their appropriate possession.

COAL AND THE COAL-TAR COLORS.

By M. DENYS COCHIN.

WITHIN thirty years, the agriculture of some countries has been subjected to an unprecedented competition. Vegetable productions identical with those they were accustomed to furnish have been extracted from stone-coal. Coal was at first employed only as a combustible; then it gave us gas and illuminating oils. Now it furnishes us perfumes and colors; the flavors of bitter-almonds and of vanilla, and the orange-red of madder, which is no longer cultivated around Avignon. We derive from coal what we used to look for in living plants, and the art of the chemist has fabricated vegetable substances. It would not, however, be correct to say that vegetable substances have been constituted from mineral elements, for coal is not a mineral, but a decomposed vegetable product. It is not pure carbon, but a mixture of hydrocarbons, of combinations which chemistry calls organic, because they proceed from living organisms and preserve a distinctive character peculiar to substances that have been endowed with life. It is not, then, the mineral world that yields us the perfumes and colors that were furnished by plants and flowers, but an intermediate world in which the remains of the vegetation of past ages are preserved.

If we heat bituminous coal in a close vessel communicating with cooled receivers, we shall have carbon left in our retort, mixed with a little sulphuret of iron. This is coke. The products of the distillation that pass over will be of two kinds; a thick liquid, coal-tar, and carbureted hydrogen gases. The gases are used for lighting. Thirty years ago the coal-tar was not used for anything. We shall proceed to inquire what profit is now derived from it. What is it precisely that takes place in the retort? Shall we believe that the light and

spongy coke was a kind of skeleton of coal intimately united with more complex substances, and that coal is a mixture of pure carbon and combined carbon? No; coal, as a whole, is a mass of substances composed of combinations of carbon with other bodies. These combinations are modified by heat. The tarry liquids and the gases do not exist in the coal, but are formed as the temperature rises in the retort. Coke is left, because in the changes that are made carbon is in excess. The coal-tar is not separated from the coke, but is made in the retort, and the bodies we find in it are results of combinations that are brought about between the substances which existed in the coal.

M. Berthelot heats to a dull red heat the gas acetylene, the molecule of which is composed of four atoms of carbon and two atoms of hydrogen. At the end of the operation the acetylene is condensed and is changed into a liquid, benzine, which is composed of twelve atoms of carbon and six of hydrogen. Three molecules of acetylene have been in some way welded together to furnish a molecule of benzine. We have seen acetylene condensed and combined as it were with itself. It also combines with hydrogen and forms olefiant gas, or ethylene. The latter unites with the benzine and gives, by synthesis, a liquid hydrocarbon, styrolene, identical with the styrolene which is produced by the styrax or Oriental liquidamber. Finally, from the union of the styrolene and the olefiant gas results naphthaline, a solid hydrocarbon, which crystallizes in thin lamellæ and abounds in coal-tar. Anthracene is one of the most valuable of the hydrocarbon extracts of coal-tar. It evidently did not exist as anthracene in the coal, but has been formed during the distillation, a solid, crystalline body, by the combination and condensation of gases.

So, when coal is heated to a very high temperature, the substances that are disengaged in a gaseous form do not always remain in that state. Heat is not always a cause of the dissolution of bodies and of the dispersion of their elements. When exposed to a temperature exceeding 1,000° C. (1,800° Fahr.) these gases condense; their molecules draw together; and they form, after a few changes, combinations richer in carbon, and consequently less volatile. We had gases, but, when our apparatus has had time to cool, we shall find liquids, even crystals. In other cases, dissociation is effected by heat. Carbonic acid, one of the most common and stable compounds in the world, the final resultant of all combustion, loses its oxygen under excessive heat, and becomes an oxidizing agent. In this way good authorities explain the production of phenic, acetic, and cresylic acids, as hydrocarbons oxidized by the oxygen of carbonic acid. The hydrocarbons may also be dissociated. A liquid hydrocarbon analogous to benzine, toluene, takes hydrogen and leaves a deposit of anthracene. Formene, or marsh-gas, a hydrocarbon which produces chloroform when the hydrogen in it is replaced with chlorine, loses hydrogen and yields anthracene.

Sometimes contrary forces are developed simultaneously, and bodies are at the same time subjected to an influence which brings them together and to another one which separates them; the result will depend upon slight differences in the temperature or in the proportions of the different bodies present. Benzine and carbonic acid unite to form benzoic acid; benzoic acid decomposes into carbonic acid and benzine. Styrolene is produced by the union of benzine and olefiant gas, and in decomposing yields benzine and acetylene. Benzine makes its appearance again if anthracene and naphthaline are heated in the presence of hydrogen. Sometimes, between these contrary forces, an equilibrium is established. Thus, acetylene will combine with hydrogen and form olefiant gas; but olefiant gas will decompose at the same temperature, giving out its two elements; while, if the three gases are present and all pure, action will be suspended, for the opposing tendencies will be counterbalanced.

These are only a few of the examples of the reactions that take place when organic substances are raised to a high temperature. The four simple substances entering into the constitution of organic bodies form among one another more compounds than are furnished by all the minerals. If heating takes place in the open air, combustion ensues, and all these innumerable substances are oxidized and dissipated in the atmosphere as carbonic acid and aqueous vapor. But, if we work in a medium free from oxygen and all other foreign elements, they react upon one another, and a multitude of bodies are formed or decomposed by the interchange of elements, and the mixture we get when the heat is removed is a mixture of new elements. So, solid and dry coal gives the coal-tar liquids and illuminating gas, which did not exist in it, but were formed under the influence of heat.

Of what organic substances coal is really composed we know only imperfectly. Chemists have not succeeded in making real analyses of it. We can tell how much of impurities, such as sulphuret of iron, it contains, and how much coal-tar and gas can be got from it; we may classify a specimen as a rich, a poor, or a bituminous coal, or as one giving a long or a short flame, but we do not separate and determine the chemical elements.

The analyst has not very many resources at his disposal for separating an intimate mixture of several bodies. The first means is that of distillation. Different bodies sublime at different temperatures, according to their various degrees of volatility; each of them, under the same atmospheric pressure, passes from the solid to the liquid state at one temperature, and from the liquid to the gaseous at another. These temperatures are called, respectively, the point of fusion and the boiling-point. Fractional distillations are performed in accordance with this principle. When the heat is raised to a certain degree, one class of bodies, at a higher temperature another class of bodies, which had not reached their boiling-point at the former temper-

ature, will be collected in the cold receiver. The operation becomes complicated and the results perplexing when the mixture consists of substances capable of being modified by the degrees of heat applied. In such cases the analysis must be carried on at a lower temperature, and the operator must depend upon solvents, the effects of which are different on different bodies. This method has been tried on coal by M. Commines de Marcilly, who employed boiling liquids or their vapors in open and in closed vessels, and in Papin's digester, by the aid of which he obtained a stronger pressure than that of the atmosphere. Acids and alkalies had no action, but neutral liquids, such as ether, benzine, sulphuret of carbon, and chloroform, were evidently colored by the coal. The experiments deserve to be carried further.

Coal-tar, the liquid product which is formed when coal is roasted in a close vessel, appears as a thick, black paste, giving no hint of the richness of the substances which may in their turn be formed and separated from it. The first product, water saturated with ammonia, passes over when the liquid is heated to between 175° and 192° Fahr. for twenty or thirty hours. Then a fractional distillation is performed, under which the light oils are separated at below 266° Fahr.; the medium oils at between 266° and 392°; and the heavy oils at between 392° and 678°; while a thick residue is left in the retort. Our study is with the oils.

The first two classes of oils are again distilled in a large alembic heated by steam under high pressure; first is collected for the medium oils all that passes between 266° and 392°. That which passes at below 266° is mixed with light oils, while the products passing at above 392° are mingled with heavy oils. The light oils are next purified in a similar manner. The latter products are known in commerce as naphtha-oils, and are chiefly carburets of hydrogen. The eighteen or twenty of them which have been distinguished form a series, in which the proportion of carbon to hydrogen increases regularly. Those least rich in carbon are gaseous; then come the liquid hydrocarbons, and last the solid compounds. We select the liquid distillates for further operations. The first step is to rid the product of the gases that may still be dissolved in it, and the alkaline or acid impurities it may contain—foreign matters which give to the naphtha a repulsive odor. They are separated by washing successively with water, which removes some of them, sulphuric acid, which acts on the alkalies, and caustic soda for the removal of acids and what excess of sulphuric acid may remain. The naphtha is then subjected to a fourth distillation, and benzine is obtained at a temperature of between 184° and 240°.

Before proceeding with the history of this valuable substance we will mention that the medium oils are treated with sulphuric acid and soda in the same way as the light oils, except that, as they are richer in alkalies and acids, they have to be treated with stronger proportions

of the cleansing agents. They are then put into the market as illuminating oils. They may also be used for solutions of India-rubber, but sulphuret of carbon is preferred for that purpose.

Faraday discovered benzine in 1825 among the products arising in the manufacture of oil-gas, and called it bicarbureted hydrogen. Mitscherlich, in 1825, in treating benzoic acid with soda, obtained a volatile liquid which he called benzine. Hofmann, in 1825, demonstrated that these two substances were the same. Berthelot explained the formation of the substance, and made a synthesis of it by heating acetylene, its molecule being composed of three molecules of that gas united, or of twelve atoms of carbon and six of hydrogen. Benzine is a type of a class of organic bodies that furnish, by substitution, innumerable series of derivatives. They are like buildings from which we can take the stones one at a time and replace them with others. They are the organic radicals, in which a number of atoms of carbon and hydrogen are associated in such a way that the energy of one atom of hydrogen is left free. In benzine, for instance, we may substitute for each atom of hydrogen an atom of chlorine and get benzine monochloride, benzine dichloride, etc., or an atom of bromine or iodine and get benzine bromide and benzine iodide ; or another radical, such as methyl or ethyl, and get methylbenzine or ethylbenzine, dimethylbenzine, trimethylbenzine, and so on. These theories permit us to account for the long series of bodies which organic chemistry has revealed, many of which are now employed in industry.

Benzine, as everybody knows, is a light liquid, perfectly colorless, and having a nauseous odor. It nevertheless furnishes perfumes and dyes. Charles Mansfield, who was the first person to utilize benzine, and make it on a large scale, announced in 1847 that he had found among the derivatives of stone-coal an oil that might take the place of the oil of bitter-almonds. It was nitrobenzine. Mitscherlich had previously produced, by the lively reaction of nitric acid on benzine, a colorless liquid, in which a compound molecule of nitrogen and oxygen was substituted for one of the six atoms of hydrogen in benzine, but his experiment never got beyond the laboratories. It was attended by too great dangers. Nevertheless, Mansfield ventured to repeat it in his shop, and succeeded in basing an industrial operation upon it. Nitrobenzine can not be pure unless the benzine was pure, and that is rarely the case with the commercial article. In the mixture of hydrocarbons, of which naphtha is constituted, are some very nearly alike in composition and in respect to their boiling-point, and it is difficult, even with the best distilling apparatus, to arrest the passage of some of them. Toluene, for example, nearly always comes over with benzine. Like it, it is attacked by nitric acid and then yields a nitrotoluene. There has also been found, associated with nitrobenzine, a peculiar yellowish-colored acid, endowed with the smell and taste of the pineapple ; and its ethers taste like the strawberry or the rasp-

berry. It has given the flavor to many a sherbet and many a confection.

Nitrobenzine is known in trade under the purely fanciful name of essence of mirbane, and is used by perfumers as a substitute for the oil of bitter-almonds—a substance which is also made artificially. It plays an important part in modern industry, because it is employed in the manufacture of aniline.

As the experiments in synthesis are continued, and more and more complicated bodies are evolved from the primitive hydrocarbon, the wealth of the field of researches open to the investigator becomes more and more surprising. How many combinations have already been effected, and how many thousand remain to be discovered! Benzine is only one of many hydrocarbons derived from coal-tar, and nitrobenzine is only one of the nitrogenized derivatives from it. There are also iodine, bromine, and chlorine derivatives, which may be obtained, not only by successive substitutions of those substances for one or more atoms of hydrogen, but also by additions of them, without displacing hydrogen. Sulpho-derivatives are also known, as well as nitrogenized derivatives of benzine chloride, iodide, and bromide. Instead of chlorine, iodine, and bromine, we may substitute organic radicals for hydrogen and get other new series. And these series of derivatives furnished by benzine are paralleled by other like series derived from toluene, xylene, and a hundred other hydrocarbons. Mathematicians exhibit a formidable total of the different possible arrangements according to which the units may be grouped by twos and threes, etc.; the seven notes of the musical scale are arranged in infinite variations; and chemistry disposes the seven or eight bodies occurring in organic matters in a similar endless diversity of combinations. If we are permitted to extend the comparison, we may say that as the musical arrangements are based upon a certain fundamental chord, so types of chemical arrangements center around a particular model, like benzine, to which it is easy to bring the whole series into relation.

Aniline exists already formed in coal-tar, but in very small quantity. Industry does not look after it, for the processes of extraction would be too costly. It is more convenient to make nitrobenzine and then reduce it, or deprive it of its oxygen by bringing it in contact with substances that will take that element from it. This may be effected by several processes. Sulphureted hydrogen, iron in fine particles, and acetic acid, are often employed as reducing agents. All the substances we have thus far derived from coal-tar are colorless. The moment has come for colors to appear. We have obtained aniline by deoxidizing nitrobenzine. If we are expecting in turn to recover nitrobenzine by oxidizing aniline, we shall find ourselves mistaken. We can, indeed, fix oxygen upon the hydrogen, but the hydrogen-atoms will separate during the process from the molecule of aniline.

Not a fixation of oxygen, but a departure of hydrogen, takes place. Then a phenomenon of condensation is exhibited; a number of the molecules unite to form a molecule of rosaniline. This wonderful colorant may be constituted by the action of almost any of the oxidizing agents known in chemistry upon aniline. Curiously, rosaniline would not be formed if the aniline were absolutely pure. Theoretically, its molecule is formed by the union of a molecule of aniline and two molecules of toluidine, with a loss between the two of six atoms of hydrogen. It can not be obtained by oxidizing either of these bases separately. Rosaniline is solid at ordinary temperatures, and crystallizes readily in lozenges or in fine needles, which are white when protected from the air, but become rose and then red when brought in contact with it. The nature of the change it undergoes is unknown. It is not apparent in the composition. Rosaniline is soluble in water, and more soluble in alcohol, and has basic qualities so strong as to displace ammonia from its salts; and it is most frequently employed as a salt. It furnishes not red only, but all colors, according as it is treated in the combinations into which it is made to enter. Violet was first discovered by Mr. Perkins, in 1856, while trying to make artificial quinine by the action of bichromate of potash on sulphate of aniline. He gave up the search for quinine, and turned his attention to manufacturing the color. Three years afterward MM. Renard and Verguin produced fuchsine, a purple salt of rosaniline, by treating commercial aniline with a dehydrogenizing agent, bichloride of tin. It is a mixture of hydrochlorate of rosaniline and salts of tin, and is used by dyers and wine-merchants. Aniline is now oxidized by the action of arsenic into *crude red* (*rouge brut*), a violet mixture, composed principally of arsenite and arseniate of rosaniline, which is converted into fuchsine by bringing about a substitution of hydrochloric for arsenious or arsenic acid. This is done by boiling crude red with hydrochloric acid, or, more usually, with sea-salt. A double decomposition takes place, and, when the liquor is cooled, crystals of fuchsine are found in the bottom of the vessel, while the arsenites and arseniates of soda are retained in the mother-water. Not all the coloring-matter, however, is deposited in the crystals, and a good operator loses nothing. Treated with carbonate of soda, the mother-water gives a precipitate, from which is extracted a color known as aniline garnet or yellow fuchsine. Nor is this all. The crude red has left a violet deposit in the bottom of the boats in which it was cooled; this is washed in boiling water; the water is colored red, and a blue dye-stuff is collected from it. More is left still. The crude red has passed through filters, and they have retained some insoluble substances. These are carefully gathered up; they form a paste which is boiled with diluted hydrochloric acid and filtered over again to extract what fuchsine is left. The insoluble residue furnishes aniline maroon, a beautiful color readily applicable to wool. Thus a single

operation has given us the violet red of fuchsine, garnet, blue, and maroon.

Whence come all of these colors? And how does chemistry explain the provision of so various hues by the same body? The differences do not arise solely from the fact that the same base, rosaniline, is found associated with different acids. We must not forget that we had at first, notwithstanding the separations effected by fractional distillations, a mixture of substances. These substances react upon one another; and the theory of their reactions, of which we have already given some idea, appears so ingenious and interesting that we must say a few words more about it.

Benzine and toluene, mixed, furnished, after some reactions, a mixture of aniline and toluidine. Two molecules of toluidine and one molecule of aniline united, with a loss of hydrogen, to form a molecule of rosaniline. Now, two molecules of aniline and one molecule of toluidine, also losing hydrogen, might also unite in a similar manner; or three molecules of aniline, or three molecules of toluidine, might be introduced in the process, with analogous results. Here we have four distinct arrangements, four possible cases, conceived in theory and realized in practice. In the first case we had rosaniline; in the second, we have mauvaniline; in the third, violaniline; and, in the fourth, chrysotoluidine. We have described the first of these substances. The second forms light-brown crystals, that become darker on heating, while the liquids in which they are dissolved take a violet tinge. Violaniline is hardly soluble, and difficult to get crystallized; it is a very dark—nearly black—brown powder. Its salts, when a few drops of concentrated sulphuric acid are added to the solution, give a dark blue. Chrysotoluidine is yellow. All these bodies are formed during the preparation of fuchsine, and are separated by filtration or through their differences in solubility, or incapacity for crystallization. The separation of the substances which do not crystallize is difficult and incomplete. The red continues united with the yellow in greater or less proportion, and gives maroon or garnet.

Through all these processes, in which we have observed the hydrocarbons decomposing one another, and forming new compounds, we have found that the chemistry of coal does not always have to borrow its powerful reagents, its acids and alkalies, from mineral chemistry; but that the compounds of carbon themselves, closely allied in constitution and properties, are very frequently capable of reacting upon and transforming one another, without the intervention of foreign agents. Instead of acids uniting with bases to give rise to a third kind of bodies, salts, we have carburets, bases, uniting by twos or by threes, with or without the loss of one of their elements, and forming double or triple molecules of compounds, which may still be of the same chemical type. The first experiments in the practical applica-

tion of these reactions were made by MM. Charles Girard and De Laire. Chemists, as we have said, understand by organic radicals certain groups of atoms of carbon and hydrogen, which are capable of combining with an atom of hydrogen in the same manner as an atom of bromine, or iodine, or chlorine, or which may be substituted for an atom of one of these substances in one of its combinations. In a complex body like rosaniline, one or more atoms of hydrogen may be removed and replaced by as many atoms of the organic radical. MM. Girard and De Laire caused aniline to react upon rosaniline. Aniline is an organic base, an ammoniacal compound. In common ammonia, one atom of nitrogen is combined with three atoms of hydrogen. In aniline, one of the atoms of hydrogen is replaced by the radical phenyle. The converse is also possible, and, if phenyle is in its turn replaced by hydrogen, the ammonia should reappear. This reaction was provoked by heating fuchsine and aniline together. Rosaniline gave up an atom of hydrogen and took the radical phenyle. Aniline lost phenyle, which was replaced by hydrogen; the ammonia was disengaged, and phenyl-rosaniline was produced. It is a bright sky-blue. We can vary its color. The exchange we have just described may be effected successively for three atoms of hydrogen against three molecules of phenyle, according to the amount of aniline employed; and we shall have monophenyle, diphenyle, or triphenyle rosaniline. The first is violet-blue, the second clear-blue, and the third a blue we might call blue-light (*bleu lumière*), because its hue loses none of its freshness—and, in fact, gains luster—even in an artificial light.

MM. Girard and Laire's discovery was of great theoretical and practical interest, and important consequences followed it. The method was general, and permitted the substitution, in most of the organic bases, of radicals for two or three atoms of hydrogen. The same chemists succeeded in doing with the hydrochlorate of aniline as they had done with the hydrochlorate of rosaniline, and obtained diphenylated and triphenylated aniline, from which they extracted blue coloring matters; then they brought the salts of these complex bases under the review of their experiments. An iodine salt of trimethylated rosaniline gave them a magnificent green, of such fixity and luster that it might be called, like the blue which they had previously prepared, green-light (*vert lumière*).

The light oils of coal-tar are almost wholly composed of carburets of hydrogen; in the heavy oils bases and acids are also found with some very condensed carburets. They contain, for example, the ready-formed aniline, which it has not been found profitable to extract from them, and phenic acid, which, besides its valuable antiseptic properties, has been serviceable to the fabricants of coloring matters. In 1834 M. Runge, in preparing phenic acid, found in the residue a yellow substance, which is called coralline, or rosolic acid. In 1859 M. Jules Persoz, heating this substance with ammonia, obtained a beau-

tiful red body, which he called peonine. Two years afterward, the manufacturers to whom he sold his patents put in the market a sky-blue substance, azuline, which also was a derivative of rosolic acid. The precise nature of rosolic acid has not been determined; but M. Fresenius has extracted an orange-yellow matter from it, which he calls aurine, and has devised a process for procuring it by heating phenic and sulphuric acids together, and adding oxalic acid six or seven hours afterward. It is not much used now, but is of interest as furnishing in itself blue, red, and yellow. The most important bodies derived from the heavy oils are naphthaline and anthracene, both carburets of hydrogen. Naphthaline, which is solid at ordinary temperatures, and crystallizes with great facility in thin lamellæ, is obtained simply by leaving the oils in the cold for five or six days, when it becomes solidified. The liquid is decanted off, and the crystals are pressed, to remove the included oil, into thick cakes. Naphthaline is a member of the same series as benzine, and is subject to a similar series of reactions. Reducing its nitrate, Zinin obtained an organic base analogous to aniline, naphthylamine, which is transformed by the loss of hydrogen into rosanaphthylamine. From this is obtained the hydrochlorate of rosanaphthylamine, a body analogous with fuchsine, of a beautiful rose-color, and easily crystallizable, but of a clearer rose with less of violet than fuchsine. It is dull when applied to wool, but gives very brilliant hues with silk. Dissolved in alcohol, it produces a strange and wonderful effect. The liquid turns bright red, and, under proper presentation to the light, may be seen to be traversed with phosphorescent clouds. If left to stand till the alcohol has slowly evaporated, the bottom of the vessel will be covered with beautiful green, iridescent needles. Naphthaline also furnishes some very complex compounds, whence have been derived very yellow dyes, among which Manchester yellow and Martins yellow are the best known. Experiments in substituting molecules of organic radicals for atoms of hydrogen, as has been done with rosaniline, have been made with some success, but the blues thus obtained have not the remarkable fixity and luster of the similar rosaniline products.

No discovery of coal-tar products is more extraordinary or more fruitful in its bearings than that of the extraction of alizarine, or the artificial preparation of the coloring principle of madder, the effect of which has been to work a real economical revolution, and to destroy the most profitable agricultural industry of large districts of country. The madder-root has furnished the most generally used of all dye-stuffs, and the one which constituted the basis of nearly all our colors. The substance to which it owes its peculiar virtues still performs the same functions, but, instead of being derived from the cultivated root, it is now procured by chemical synthesis from stone-coal.

Alizarine is prepared from anthracene, the second of the more important bodies which we have already spoken of as contained in the

heavy oils of coal-tar. It forms a part of the deposit of solids which forms when the heavy oils are left standing in the cold, from which are obtained the crystals of naphthaline. When this deposit is raised to a temperature of 250° C. (482° Fahr.), the naphthaline and the indefinite oily substances are distilled away, and there is left anthracene, with some impurities. The impurities may be removed by means of the very light oils of petroleum, which dissolve them and leave the anthracene; or by the light oils of coal-tar, which dissolve the anthracene and leave them. When anthracene has been sufficiently purified it is submitted to the action of oxidizing agents, and anthraquinone is obtained by precipitation as a resultant. By this direct process we have made a ternary body of our hydrocarbon, and have combined it with a proportion of oxygen which we can not increase by any further process of a direct character; but the alizarine which we are seeking to get is richer in oxygen than anthraquinone. The second degree of oxidation has to be attained by an indirect process; we bring it about by withdrawing some atoms of hydrogen from the molecule and substituting for them molecules containing oxygen. The authors of the synthesis accomplished it in a process of two steps, by putting bromine in place of hydrogen and the elements of water in place of the bromine. But bromine is expensive, and so the manufacturers now make alizarine, not from a bromized but from a sulphureted anthraquinone. Of all the coloring substances derived from coal-tar, alizarine is the one which is now made in the greatest quantity. According to the report of M. Würtz, made in 1878, eight factories, two of which were very extensive, were then in full activity in Germany, two in Switzerland, one in England, and one in France, which last the proprietors had had the courage to establish in the very center of the madder-raising district. The quantity of alizarine then produced was estimated at 3,500 kilogrammes, or nearly 9,000 pounds daily, and it has doubtless been since considerably increased.

Anthracene, the basis of the manufacture of alizarine, is relatively abundant in coal-tar, forming sometimes from seven to eight per cent of its mass. It has been observed that coal-tar is rich in anthracene in proportion as it is poor in toluene, and M. Berthelot has explained the fact by showing that toluene, decomposed by heat, produces anthracene; hence the relative amount obtained of either is likely to vary according to the temperature-conditions of the distillation. The differences may also probably depend upon the character of the coal and of the matter first employed at the point of departure of all the operations. But, as we have said, this point of departure is essentially unknown. All of our products have been obtained from a vegetable or organic, not from the primary mineral, carbon; not from carbon either, but from compounds of carbon and hydrogen of a character which we have not yet been able to produce by synthesis of the primary mineral elements, but which the sun stored up for us ages ago, working

through the agency of organic growth. From a black and amorphous matter we have made to issue crystalline substances of every shade of color—reds, saffrons, greens, violets, and blues—alizarine, the same substance as tints the flowers of the madder, and that wonderful aniline, colorless as the ray of light before it has been resolved by the prism, but containing *in posse*, like the same ray, all the colors of the rainbow. What do we know of stone-coal, the origin of so many marvels and refractory to all analysis? Nothing, except that it has lived.—*Translated for the Popular Science Monthly from the Revue des Deux Mondes.*

THE CHEMISTRY OF COOKERY.

By W. MATTIEU WILLIAMS.

XXX.

THE changes which occur when starch-granules are subjected to the action of water, at a temperature of 140°, have been described. If the heat is raised to the boiling-point, and the boiling continues, the gelatinous mass becomes thicker and thicker; and if there are more than fifty parts of water to one of starch a separation takes place, the starch settling down with its fifty parts of water, the excess of water standing above it. Carefully-dried starch may be heated to above 300° without becoming soluble, but at 400° a remarkable change commences. The same occurs to ordinary commercial starch at 320°, the difference evidently depending on the water retained by it. If the heat is continued a little beyond this it is converted into *dextrin*, otherwise named "British gum," "gommeline," "starch-gum," and "Alsace gum," from its resemblance to gum-arabic, for which it is now very extensively substituted. Solutions of this in bottles are sold in the stationers' shops under various names for desk uses.

The remarkable feature of this conversion of starch into dextrin is that it is accompanied by no change of chemical composition. Starch is composed of six equivalents of carbon, ten of hydrogen, and five of oxygen—$C_6H_{10}O_5$, i. e., six of carbon and five of water or its elements. Dextrin has exactly the same composition; so also has gum-arabic when purified. But their properties differ considerably. Starch, as everybody knows, when dried, is white, and opaque and pulverent; dextrin, similarly dried, is transparent and brittle; gum-arabic the same. If a piece of stareh, or a solution of starch, is touched by a solution of iodine, it becomes blue almost to blackness, if the solution is strong; no such change occurs when the iodine solution is added to dextrin or gum. A solution of dextrin when mixed with potash changes to a rich blue color when a little sulphate of cop-

per is added; no such effect is produced by gum-arabic, and thus we have an easy test for distinguishing between true and fictitious gum-arabic.

The technical name for describing this persistence of composition with changes of properties is *isomerism*, and bodies thus related are said to be *isomeric* with each other. Another distinguishing characteristic of dextrin is that it produces a right-handed rotation on a ray of polarized light—hence its name, from *dexter*, the right.

The conversion of starch into dextrin is a very important element of the subject of vegetable cooking, inasmuch as starch-food can not be assimilated until this conversion has taken place, either before or after we eat it. I will therefore describe other methods by which this change may be effected.

If starch be boiled in a dilute solution of almost any acid, it is converted into dextrin. A solution containing less than one per cent of sulphuric or nitric acid is sufficiently strong for this purpose. One method of commercial manufacture (Payen's) is to moisten ten parts of starch with three of water, containing $\frac{1}{100}$ of its weight of nitric acid, spreading the paste upon shelves, allowing it to dry in the air, and then heating it for an hour and a half at about 240° Fahr.

But the most remarkable and interesting agent in effecting this conversion is *diastase*. It is one of those mysterious compounds which have received the general name of "ferments." They are disturbers of chemical peace, molecular agitators that initiate chemical revolutions, which may be beneficent or very mischievous. The morbific matter of contagious diseases, the venom of snake-bite, and a multitude of other poisons, are ferments. Yeast is a familiar example of a ferment, and one that is the best understood. I must not be tempted into a dissertation on this subject, but may merely remark that modern research indicates that many of these ferments are microscopic creatures, linking the vegetable with the animal world; they may be described as living things, seeing that they grow from germs and generate other germs that produce their like. Where this is proved, we can understand how a minute germ may, by falling upon suitable nourishment, increase and multiply, and thus effect upon large quantities of matter the chemical revolution above named.

I have already described the action of rennet upon milk, and the very small quantity which produces coagulation. There appears to be no intercession of living microbia in this case, nor have any been yet demonstrated to constitute the ferment of diastase, though they may be suspected. Be this as it may, diastase is a most beneficent ferment. It communicates to the infant plant its first breath of active life, and operates in the very first stage of animal digestion.

In a grain of wheat, for example, the embryo is surrounded with its first food. While the seed remains dry above-ground there is no assimilation of the insoluble starch or gluten, no growth, nor other

sign of life. But when the seed is moistened and warmed, the starch is changed to dextrin by the action of diastase, and the dextrin is further converted into sugar. The food of the germ thus gradually rendered soluble penetrates its tissues; it is thereby fed and grows, unfolds its first leaf upward, throws downward its first rootlet, still feeding on the converted starch until it has developed the organs by which it can feed on the carbonic acid of the air and the soluble minerals of the soil. But for the original insolubility of the starch it would be washed away into the soil, and wasted ere the germ could absorb it. The maltster, by artificial heat and moisture, hastens this formation of dextrin and sugar; then by a roasting heat kills the baby plant just as it is breaking through the seed-sheath. Blue-ribbon orators miss a point in failing to notice this. It would be quite in their line to denounce with scathing eloquence such heartless infanticide.

Diastase may be obtained by simply grinding freshly germinated barley or malt, moistening it with half its weight of warm water, allowing it to stand, and then pressing out the liquid. One part of diastase is sufficient to convert two thousand parts of starch into dextrin, and from dextrin to sugar, if the action is continued. The most favorable temperature for this is from 140° to 150° Fahr. The action ceases if the temperature be raised to the boiling-point.

The starch which we take so abundantly as food appears to have no more food-value to us than to the vegetable germ until the conversion into dextrin or sugar is effected. From what I have already stated concerning the action of heat upon starch, it is evident that this conversion is more or less effected in some processes of cookery. In the baking of bread an incipient conversion probably occurs throughout the loaf, while in the crust it is carried so far as to completely change most of the starch into dextrin, and some into sugar. Those of us who can remember our bread-and-milk may not have forgotten the gummy character of the crust when soaked. This may be felt by simply moistening a piece of crust in hot water and rubbing it between the fingers. A certain degree of sweetness may also be detected, though disguised by the bitterness of the caramel, which is also there.

The final conversion of starch-food into dextrin and sugar is effected in the course of digestion, especially, as already stated, in the first stage—that of insalivation. Saliva contains a kind of diastase, which has received the name of *salivary diastase* and *mucin*. It does not appear to be exactly the same substance as vegetable diastase, though its action is similar. It is most abundantly secreted by herbivorous animals, especially by ruminating animals. Its comparative deficiency in carnivorous animals is shown by the fact that, if vegetable matter is mixed with their food, starch passes through them unaltered.

Some time is required for the conversion of the starch by this animal diastase, and in some animals there is a special laboratory or kitchen for effecting this preliminary cookery of vegetable food. Ruminating animals have a special stomach-cavity for this purpose in which the food, after mastication, is held for some time and kept warm before passing into the cavity which secretes the gastric juice. The crop of grain-eating birds appears to perform a similar function. It is there mixed with a secretion corresponding to saliva, and is thus partially malted—in this case *before* mastication in the gizzard.

At a later stage of digestion, the starch that has escaped conversion by the saliva is again subjected to the action of animal diastase contained in the pancreatic juice, which is very similar to saliva.

It is a fair inference from these facts that creatures like ourselves, who are not provided with a crop or compound stomach, and manifestly secrete less saliva than horses or other grain-munching animals, require some preliminary assistance when we adopt graminivorous habits; and one part of the business of cookery is to supply such preliminary treatment to the oats, barley, wheat, maize, peas, beans, etc., which we cultivate and use for food.

XXXI.

Having described the changes effected by heat upon starch, and referred to its further conversion into dextrin and sugar, I will now take some practical examples of the cookery of starch-foods, beginning with those which are composed of pure, or nearly pure, starch.

When arrowroot is merely stirred in cold water it sinks to the bottom undissolved and unaltered. When cooked in the usual manner to form the well-known mucilaginous or jelly-like food, the change is a simple case of the swelling and breaking up of the granules described as occurring in water at the temperature of 140° Fahr. There appears to be no reason for limiting the temperature, as the same action takes place from 140° upward, to the boiling-point of water.

I may here mention a peculiarity of another form of nearly pure starch-food, viz., tapioca, which is obtained by pulping and washing out the starch-granules of the root of the *manihot*, then heating the washed starch in pans and stirring it while hot with iron or wooden paddles. This cooks and breaks up the granules and agglutinates the starch into nodules which, as Mr. James Collins explains ("Journal of Society of Arts," March 14, 1884), are thereby coated with dextrin, to which gummy coating some of the peculiarities of tapioca-pudding are attributable. It is a curious fact that this manihot-root, from which our harmless tapioca is obtained, is terribly poisonous. The plant is one of the large family of nauseous spurgeworts (*Euphorbiaceæ*). The poison resides in the milky juice surrounding the starch-granules, but, being both soluble in water and volatile, most of it is washed away in separating the starch-granules, and any that remains after washing is

driven off by the heating and stirring which has to reach 240°, in order to effect the changes above described.

I suspect that the difference between the forms of tapioca and arrowroot has arisen from the necessity of thus driving off the last traces of the poison with which the aboriginal manufacturers were so well acquainted as to combine the industry of poisoning their arrows with that of extracting the starch-food from the same root. No certificate from the public analyst is demanded to establish the absence of the poison from any given sample of tapioca, as the juice of the manihot-root, like that of other spurges, is unmistakably acrid and nauseous.

Sago, which is a starch obtained from the pith of the stem of the sago-palm and other plants, is prepared in grains like tapioca, with similar results. Both sago and tapioca contain a little gluten, and therefore have more food-value than arrowroot.

The most familiar of our starch-foods is the potato. I place it among the starch-foods, as, next to water, starch is its prevailing constituent, as the following statement of average compositions will show: Water, 75 per cent; starch, 18·8; nitrogenous materials, 2; sugar, 3; fat, 0·2; salts, 1. The salts vary considerably with the kind and age of the potato, from 0·8 to 1·3 in full grown. Young potatoes contain more. In boiling potatoes, the change effected appears to be simply a breaking up or bursting of the starch-granules, and a conversion of the nitrogenous gluten into a more soluble form, probably by a certain degree of hydration. As we all know, there are great differences among potatoes, some are waxy, others floury; and these, again, vary according to the manner and degree of cooking. I can not find any published account of the chemistry of these differences, and must, therefore, endeavor to explain them in my own way.

As an experiment, take two potatoes of the floury kind; boil or steam them together until they are just softened throughout, or, as we say, "well done." Now leave one of them in the saucepan or steamer, and very much overcook it. Its floury character will have disappeared, it will have become soft and gummy. The reader can explain this by simply remembering what has already been explained concerning the formation of dextrin. It is due to the conversion of some of the starch into dextrin. My explanation of the difference between the waxy and floury potato is that the latter is so constituted that all the starch-granules may be disintegrated by heat in the manner already described, before any considerable proportion of the starch is converted into dextrin, while the starch of the waxy potatoes for some reason, probably a larger supply of diastase, is so much more readily convertible into dextrin that a considerable proportion becomes gummy before the whole of the granules are broken up—i. e., before the potato is cooked or softened throughout.

I must here throw myself into the great controversy of jackets or

no jackets. Should potatoes be peeled before cooking, or should they be boiled in their jackets? I say most decidedly in jackets, and will state my reasons. From 53 to 56 per cent of the above-stated saline constituents of the potato is potash, and potash is an important constituent of blood—so important that in Norway, where scurvy once prevailed very seriously, it has been banished since the introduction of the potato, and, according to Lang and other good authorities, it is owing to the use of this vegetable by a people who formerly were insufficiently supplied with saline vegetable food.

Potash salts are freely soluble in water, and I find that the water in which potatoes have been boiled contains potash, as may be proved by boiling it down to concentrate, then filtering and adding the usual potash test, platinum chloride.

It is evident that the skin of the potato must resist this passage of the potash into the water, though it may not fully prevent it. The bursting of the skin only occurs at quite the latter stage of the cookery. The greatest practical authorities on the potato, Irishmen, appear to be unanimous. I do not remember to have seen a pre-peeled potato in Ireland. I find that I can at once detect by the difference of flavor whether a potato has been boiled with or without its jacket, and this difference is evidently saline.

These considerations lead to another conclusion, viz., that baked potatoes, and fried potatoes, or potatoes cooked in such a manner so as to be eaten with their own broth, as in Irish stew (in which cases the previous peeling does no mischief), are preferable to boiled potatoes. Steamed potatoes probably lose less of their potash juices than when boiled; but this is uncertain, as the modicum of distilled water condensed upon the potato and continually renewed may wash away as much as the larger quantity of hard water in which the boiled potato is immersed.

Those who eat an abundance of fruit, of raw salads, and other vegetables supplying a sufficiency of potash to the blood, may peel and boil their potatoes; but the poor Irish peasant who depends upon the potato for all his sustenance requires that they shall supply him with potash.

When traveling in Ireland (I explored that country rather exhaustively when editing the fourth edition of "Murray's Hand-book"), I was surprised at the absence of fruit-trees in the small farms where one might expect them to abound. On speaking of this, the reason given was that all trees are the landlord's property; that if a tenant should plant them they would suggest luxury and prosperity, and therefore a rise of rent; or, otherwise stated, the tenant would be fined for thus improving the value of his holding. This was before the passing of the Land Act, which we may hope will put an end to such legalized brigandage. With the abolition of rack-renting, the Irish peasant may grow and eat fruit; may even taste jam without fear and

trembling; may grow rhubarb and make pies and puddings in defiance of the agent. When this is the case, his craving for potato-potash will probably diminish, and his children may actually feed on bread.

As regards the nutritive value of the potato, it is well to understand that the common notion concerning its cheapness as an article of food is a fallacy. Taking Dr. Edward Smith's figures, 760 grains of carbon and 24 grains of nitrogen are contained in one pound of potatoes; two and one half pounds of potatoes are required to supply the amount of carbon contained in one pound of bread; and three and one half pounds of potatoes are necessary for supplying the nitrogen of one pound of bread. With bread at three halfpence per pound, potatoes should cost less than one halfpenny per pound, in order to be as cheap as bread for the hard-working man who requires an abundance of nitrogenous food.

My own observations in Ireland have fully convinced me of the wisdom of William Cobbett's denunciation of the potato as a staple article of food. The bulk that has to be eaten, and is eaten, in order to sustain life, converts the potato-feeder into a mere assimilating machine during a large part of the day, and renders him unfit for any kind of vigorous mental or bodily exertion. If I were the autocratic Czar of Ireland, my first step toward the regeneration of the Irish people would be the introduction, acclimatizing, and dissemination of the Colorado beetle, in order to produce a complete and permanent potato-famine. The effect of potato-feeding may be studied by watching the work of a potato-fed Irish mower or reaper who comes across to work upon an English farm where the harvest-men are fed in the farm-house and where beer is not excessive. The improvement of his working powers after two or three weeks of English feeding is comparable to that of a horse when fed upon corn, beans, and hay, after feeding for a year on grass only.

The reader may have observed that the starch-foods already described are all derived from the roots or stems of plants. Many others might be named that are used in tropical climates where little labor is demanded or done, and but little nitrogenous food required. Having treated the cookery of the chief constituents of these parts of the plant, the fiber and the starch, I now come to food obtained from the seeds and the leaves.

Taking the seeds first, as the more important, it becomes necessary to describe the nitrogenous constituents which are more abundant in them than in any other part of the plant, though they also contain the starch and cell material, or woody fiber, as already stated.

In No. 29 of this series, page 65, I described a method of separating starch from flour by washing a piece of dough in water, and thereby removing the starch-granules, which fall to the bottom of the water. If this washing is continued until no further milkiness of the water is produced, the piece of dough will be much reduced in dimen-

sions, and changed into a gray, tough, elastic, and viscous or glutinous substance, which has been compared to bird-lime, and has received the appropriate name of *gluten*. When dried, it becomes a hard, horny, transparent mass. It is insoluble in cold water, and partly soluble in hot water. It is soluble in strong vinegar, and in weak solutions of potash or soda. If the alkaline solution is neutralized by an acid, the gluten is precipitated.

If crude gluten obtained as above is subjected to the action of hot alcohol it is separated into two distinct substances, one soluble and the other insoluble. As the solution cools, a further separation takes place of a substance soluble in hot alcohol, but not in cold, and another soluble in either hot or cold alcohol. The first—viz., that insoluble in either hot or cold alcohol—has been named *gluten-fibrin;* that soluble in hot alcohol, but not in cold, *gluten-casein;* and that soluble in either hot or cold alcohol, *gluten*. I give these names and explain them, as my readers may be otherwise puzzled by meeting them in books where they are used without explanation, especially as there is another substance, presently to be described, to which the name of vegetable casein has also been applied. The gluten-fibrin is supposed to correspond with blood-fibrin, gluten-casein with animal casein, and gluten with albumen.—*Knowledge.*

ENSILAGE AND FERMENTATION.

By MANLY MILES, M. D.

THE preservation of green fodder in the form of ensilage is now attracting so large a share of the attention of practical farmers, that a brief sketch of the history of the process, and an outline of the known facts in regard to fermentation, must be of interest to the general reader, as well as the student who wishes to trace the laws of evolution in the development of improved methods in agriculture.

Nearly thirty years ago, Adolf Reihlen, who owned a sugar-factory near Stuttgart, in Germany, preserved a crop of fodder-corn, which had been injured by frost, by burying it in trenches or pits, and covering it with the soil thrown out to protect it from the atmosphere. This method of preserving corn-fodder was suggested by the well-known process of making "brown or sour hay" by packing newly-cut grass in pits, which had been practiced for many years by farmers in Europe.

When the pits were opened, several months afterward, the fodder-corn had a greenish color and a peculiar odor, but its value as cattle-food was not apparently diminished. M. Reihlen was so well pleased with the results of his experiment, that he made a practice of "pitting" a quantity of fodder-corn every year, to obtain a supply of succulent feed for his cattle during the winter.

In 1870 M. Vilmorn called the attention of French farmers to the advantages of this method of preserving green fodder, which M. Reihlen had then successfully practiced for many years. The new method was so favorably received and extensively introduced in France, that it soon became known as the French system of ensilage. The application to a new crop of the old system of curing grass as "brown or sour hay" was in fact accepted as a practically new method, which was designated as the "ensilage of maize."

M. Morel seems to have been the pioneer in the practice of the new system, the results of his experience having been published in the "Journal d'Agriculture pratique" of October 19, 1871. Others, encouraged by this report, followed his example, and for several years the "ensilage of maize" was the leading topic of discussion in the agricultural papers of France. In 1877 M. Auguste Goffart published, in Paris, a work on ensilage, giving his experience for several years with silos of masonry above ground, in which the covers of boards were loaded to give a continuous pressure to the mass, and thus exclude the air. The covering and weighting of the silo, as practiced by M. Goffart, was an improvement on former methods, and it appears to be the only point on which he can make a claim of originality. A translation of this work, which has been the standard authority on ensilage, was published in New York in 1878, and had a marked influence on the introduction of the system in this country.

As early as 1873 agricultural papers in Great Britain and America gave occasional brief notices of the preservation of green fodder in pits as practiced in France and Germany, and the process was usually referred to as the "potting" or "pitting" of fodder.

In 1875 three earth-silos were filled with fodder-corn and broom-corn seed, under my direction, in Illinois, with results that were quite satisfactory. These experiments were reported in "The Country Gentleman" in 1876, page 627, together with an account of the experience of several French farmers who had used ensilage on a large scale. In this paper the French terms "silo" and "ensilage" were introduced, as they had a definite meaning not well expressed by any English words, and they are now in common use.

Mr. Francis Morris, of Maryland, who has had the credit of making the first experiments with ensilage in this country, made his first silo in 1876. Others soon followed his example, and now we find silos in every part of the country, and ensilage has become a familiar cattle-food. The first silos, as we have seen, were simple pits dug in the ground, and the soil thrown out was used to cover and protect the ensilage. In many soils these pits served but a temporary purpose; and the next step in their development was a lining of masonry to give the pits a permanent character. From the difficulty of keeping the water out of these pits, in many localities, silos of masonry were made above ground, and these at first were massive and expensive.

The next step in advance, which quite naturally followed, was, to substitute a movable cover of boards, with weights to give the required pressure, for the cover of earth which had been used in the less perfect form of the silo. As an air-tight inclosure was found to be the essential condition in the construction of a silo, lighter walls were made as a matter of economy, with good results, and even frames of timber, lined with boards or planks, were substituted for the more expensive structures, with complete success.

A balloon-frame of scantling, of suitable size, covered on the outside with matched boards, and lined on the inside with two thicknesses of one-inch matched boards, with a layer of tarred paper between them, thus securing a practically air-tight inclosure surrounded by a dead-air space as a protection against frost, is, in the opinion of the writer, the best and cheapest form of construction. If the boards and timbers are saturated with hot coal-tar, which can readily be done with trifling expense, the durability of the silo will be very much increased. From the fact that wood is not so good a conductor of heat as walls of masonry, it will be seen, from what follows, that wooden silos may have an important advantage over any others in preserving the ensilage, which, in connection with the saving of expense in their construction, must have an influence in bringing them into general use.

There are many conflicting statements in regard to the value of ensilage as a cattle-food, and it may be that the failure to realize the exaggerated claims that were made for it when first introduced has resulted in a reaction which naturally leads to a low estimate of its value. It must, however, be admitted that a large proportion of the farmers who have used it are fully satisfied that it is a desirable and valuable form of cattle-food, and many would not limit its use to the winter months. Others speak with less confidence of the results of their experience, and are inclined to admit, with those who are not convinced of the utility of the process, that the acidity which is developed to a greater or less extent, in most cases, is decidedly objectionable. Experience at the condensed-milk factories is claimed to be unfavorable to ensilage as food for cows, and some of them refuse to receive milk from farms where it is fed.

That there are great differences in the quality of the ensilage made on different farms, or even in that made on the same farm in different seasons, there can be no doubt, and these differences must be attributed to variations in the conditions under which the ensilage is made, which must result in corresponding modifications of the process of fermentation. When the influence of these varying conditions, which include the peculiarities of the crop, as well as the method of filling the silo, is so well understood that ensilage of a uniform and desired quality can be produced with certainty, the most important objections that are now made to it will be obviated, and it will readily take its place on the farm as a staple article of cattle-food.

My studies of ensilage have for some time past been directed to methods of preventing acidity and securing a desirable degree of uniformity in quality, and thus far the results are, to say the least, encouraging. The experimental silo at the Massachusetts experiment station was made under my direction, on the plan of the wooden silo described above. It was filled in two and a half days with over seventeen tons of fodder-corn, cut in one and a fourth inch lengths, and thoroughly packed as it was put in. A tight cover made of two thicknesses of planed boards and planks was put on, and loaded with barrels of earth that were estimated to give a pressure of over sixty pounds per square foot. For convenience of access to the interior of the mass, a gas-pipe one and a fourth inch in diameter was driven through a hole in the middle of the cover, to the depth of four feet, the upper end being carefully packed to make a tight connection with the planks of the cover, and the upper end was closed with a plug.

When the cover was put on, September 8th, the temperature was 82° Fahr., two feet below the surface. Observations were made from time to time, of the temperature and rate of settling, as recorded in the following table:

DATE.	Depth of ensilage.	Temperature of ensilage four feet from the surface.	Temperature of outside air.
	Ft. In.	Degrees Fahr.	Degrees Fahr.
September 8th	8 6	82	..
" 9th	7 7	82	..
" 10th	7 2⅜	78	..
" 11th	6 9	77	..
" 12th	....	82	62
" 14th	....	84	55
" 15th	5 11½	84	68
" 16th	5 11½	87	72
" 17th	5 10½	85	69
" 18th	5 9⅝	82	59
" 19th	5 9⅝	84	..
" 20th	5 9½	84	61
" 21st	5 9½	84	62
" 22d	5 9	83	56
" 24th	5 9	82	61
" 25th	5 8½	80	58
" 26th	5 8½	80	50
" 27th	5 7⅝	80	50
" 28th	5 7½	80	60
" 29th	5 7½	79	53
" 30th	5 7½	78	59
October 1st	5 7½	78	50
" 2d	5 7½	76	48
" 3d	5 7	76	44
" 4th	5 6⅞	76	43
" 10th	....	68	..
" 27th	....	65	..
November 7th	....	64	..
" 18th	....	59	..
December 3d	....	54	..
" 15th	5 5½	49	22

The weights as applied gave a uniform pressure; but the cover, as will be seen from the table, did not settle at a uniform rate. There was a fall of 5° in temperature during the first three days, then followed a gradual but not uniform rise, until the maximum of 87° was reached at the end of the first week. It will likewise be noticed that a variation of but 5° from the initial temperature occurred during the first three weeks after the cover was put on and weighted, and that the fall in the temperature was not uniform.

Experiments were repeatedly made with samples of ensilage, taken through the tube, from the interior of the silo. The samples obtained on the 9th of September swarmed with bacteria, which were remarkably active and rapidly increasing by self-division. After the first few days the indications of rapid reproduction were not so marked, but the activity of the bacteria was not sensibly diminished until the temperature had fallen below 60°, more than two months after the silo was filled. The variations in temperature and in the rate of settling were undoubtedly connected with the vital activity of the bacteria, but the precise relation of these variations could not be traced.

The real significance of these minute organisms can not be fully appreciated without a review, including a brief history, of the known facts of the process of

Fermentation.—The alchemists were acquainted with ferments and fermentation as early as the thirteenth century, but we need not stop to notice their crude theories in regard to the process. In 1659, Willis, an English physician, presented a theory of fermentation, which was revived by Stahl, the originator of the phlogiston theory, in 1697. According to the theory of these philosophers, ferments had a peculiar motion of their particles which they communicated to the particles of fermentable substances and thus produced fermentation. The discovery of carbonic acid by Black (1752), of oxygen by Priestley (1774), and of the composition of the atmosphere and water by Cavendish (1781), laid the foundation for the experiments of Lavoisier, who attempted a quantitative determination of the changes taking place in the transformation of sugar into alcohol. Gay-Lussac (1815) revised the figures obtained by Lavoisier, by less perfect methods, and made a close approximation to a correct formula. In 1828 Dumas and Boullay pointed out and corrected errors in the formulæ of Gay-Lussac, and in this amended form they were, for many years, accepted as an accurate statement of the phenomena of alcoholic fermentation. Afterward, however, the discovery was made that glycerine and succinic acid are constant products of the process, and the formulæ had to be again corrected. These formulæ, even in their amended form, did not take into the account the yeast which had been recognized as an essential element in the process, and theories were formed to account for its action. Berzelius attributed the influence of yeast to a "catalytic" action—mere contact with the ferment being sufficient to excite fer-

mentation in a fermentable substance without any other direct relation. In 1840 Liebig presented a theory of fermentation which was generally adopted by chemists. He recognized fermentation and putrefaction as essentially similar processes. Albuminoid substances, from the complex arrangement of their molecules, were assumed to be in a state of unstable equilibrium tending to decomposition, and their putrefactive transformations, which were communicated to fermentable substances, were the cause of fermentation. He claimed that "yeast produces fermentation in consequence of the progressive decomposition which it suffers from the action of air and water." Fermentation and putrefaction were claimed to be processes of combustion or oxidation. This theory was more fully elaborated, in 1848, by assigning to the decomposing albuminoid ferments a peculiar molecular motion which communicated to fermentable substances a similar vibration of their particles, and a consequent decomposition. This was in fact but a revival of the theory of Willis and Stahl more than two hundred years before. Notwithstanding its general acceptance by chemists, Liebig's theory failed to recognize one of the essential factors of fermentation, and we must now turn our attention to a brief outline of some of the discoveries which disproved it, and furnished on the other hand a complete and satisfactory explanation of the process.

Leeuwenhoek, in 1680, made the discovery that yeast was composed of minute granules, but, with the imperfect lenses of that time, he failed to determine their real character. Fabroni, in 1787, described the yeast-granules as a vegeto-animal substance; and Astier, as early as 1813, claimed that this ferment was endowed with life, and derived its nourishment from the fermenting materials, thus causing fermentation. About 1838 Cagniard-Latour and Schwann, by independent observations, rediscovered the yeast-granules of Leeuwenhoek, and, by means of the better microscopes at their command, succeeded in proving that they were vegetable cells which were reproduced by budding. Schwann, by a series of ingenious experiments, proved that the germs of the living ferments were conveyed to fermentable substances by the air, and that they were the cause of fermentation, while the free admission of oxygen, under conditions that excluded the germs, was without effect. The experiments of Schwann were, in themselves, sufficient to establish the truth of the physiological theory of fermentation, but they were entirely ignored by Liebig and the advocates of his chemical theory. A complete demonstration of the true theory of fermentation was finally made by Pasteur (1857–'79) in a series of experiments which, from the skill displayed in their conception, and the remarkable accuracy secured in conducting them in accordance with strictly inductive methods, may safely be classed among the most brilliant records in the history of science. He repeated the experiments of his predecessors, invented new methods of investigation by which he was enabled to eliminate all possible sources of error, and answered his opponents by

an accumulation of experimental evidence that could not be controverted. He proved that sugar was acted upon by a variety of ferments, each giving its own peculiar product, and that the different kinds of fermentation, properly so called, as the alcoholic, the lactic, the acetic, the viscous, the butyric, and putrefactive, were each the result of the vital activity of distinct and specific organisms.

Ferments are now generally divided into two classes: 1. The so-called soluble or chemical ferments, as acids and diastase, which "invert" cane-sugar and transform it into dextrose, or change starch into dextrin. These soluble ferments, according to Dumas, "always sacrifice themselves in the exercise of their activity," but they do not produce fermentation in the strict sense of the term. 2. The true ferments, which, through the investigations of Pasteur, are now known to be living organisms that produce fermentation as a function of their vital activity. Unlike the soluble ferments, these living organisms increase at the expense of the substances fermented. The true fermentations are therefore purely physiological processes, which are defined by Pasteur as "the direct consequence of the processes of nutrition, assimilation, and life, when they are carried on without the agency of free oxygen," or, "as a result of life without air."

The organized ferments, which belong to the class of fungi, may be divided into two groups, the saccharomycetes, or budding fungi—the active agents of alcoholic fermentation, of which yeast may be taken as the type—and the schizomycetes, or fission fungi, which include the lactic, the butyric, and similar ferments, and the organisms that produce putrefaction; most of them are of the form known as bacteria, and they multiply rapidly by subdivision. It is probable that all the members of both groups propagate by means of spores, as well as by their special processes of budding and fission, but there are many species in which reproduction by spores has not been observed. The living organisms (bacteria) found in samples of fresh ensilage belong to the group of schizomycetes. Thus far no members of the group of saccharomycetes (yeast or alcoholic ferments) have been observed, by me, in samples from the interior of the silo that had not been exposed to the air. When a large surface of ensilage is exposed to the air, after the silo is opened, a variety of ferments may make their appearance, and with them several species of molds, but they are evidently produced from germs derived from the air.

The mold-fungi are not included in the class of ferments, as Pasteur has proved that they act as ferments under exceptional conditions only, and even then they do not produce active fermentation. The alcoholic ferments have been studied more thoroughly than the others, from their importance in the manufacture of beer, wine, etc., but many of the facts developed in their investigation are undoubtedly applicable to other ferments.

From Pasteur's experiments with fruits in an atmosphere of car-

bonic acid, it appears that any vegetable cells which are capable of extracting their needed supply of oxygen from organic combinations may, by this manifestation of their vital activity, act as ferments, and the true ferments are distinguished from these, not by a difference in their specific action, but from the fact that they are capable of carrying on the functions of nutrition and assimilation with much greater activity without a supply of atmospheric oxygen. Pasteur has likewise proved that the alcoholic ferments develop rapidly in the presence of air, but that their function as ferments is impaired by this ready supply of oxygen. In the absence of air, on the other hand, as in an atmosphere of carbonic acid, they take their supply of oxygen from organic substances, as sugar, and their function as ferments is increased. When the life of the bacteria or other organized ferments is destroyed, the processes of fermentation and putrefaction cease, and this takes place at a temperature of from 122° to 140°, according to observations made in the course of the controversy in regard to spontaneous generation. After the organized ferments are killed, fermentation or putrefaction can not take place until the living ferments are again introduced. The canned articles of food which are now so common in the markets are an illustration of the application of this principle. In their preparation heat is applied, which kills the bacteria—the active agents of fermentation—and the cans are then sealed to prevent the introduction of a fresh supply of germs from the atmosphere. The popular notion that canned articles of food are preserved by excluding the atmospheric oxygen, which has been derived from the application of Liebig's chemical theory of fermentation, is without foundation. The experiments of Schwann, Pasteur, and Tyndall conclusively prove that articles which are peculiarly liable to undergo putrefactive changes, as urine, and an endless variety of vegetable and animal infusions, can be kept without change for months and years when abundantly supplied with free oxygen, if proper precautions are taken to exclude the living organisms that are the real cause of fermentation. These experiments have likewise proved that the germs of the bacteria of fermentation and putrefaction are widely distributed in the air, and the supposed cases of spontaneous fermentation, or putrefaction, are readily explained by the "seeding" of the fermenting substances with germs derived from the atmosphere.

As fermentation is strictly a physiological process, the fermented product may be looked upon as the residuum of what is required in the nutritive processes of the bacteria of fermentation.

The variations in the quality of ensilage, to which attention has already been directed, are readily explained by differences in the condition of the crops, as to maturity and development, and the manner in which it is packed in the silo, all of which must have an influence on the performance of the nutritive functions of the bacteria, and cor-

responding variations will consequently be presented in the residual or fermented product. As in other cases involving the activity of living organisms the molecular changes taking place under such different conditions can not be expressed in any definite chemical formula.

In advocating these views, Pasteur says: "Originally, when fermentations were put among the class of decompositions by contact-action, it seemed probable, and in fact was believed, that every fermentation had its own well-defined equation, which never varied. In the present day, on the contrary, it must be borne in mind that the equation of a fermentation varies essentially with the conditions under which that fermentation is accomplished, and that a statement of this equation is a problem no less complicated than that in the case of the nutrition of a living being. To every fermentation may be assigned an equation in a general sort of way—an equation, however, which, in numerous points of detail, is liable to the thousand variations connected with the phenomena of life. Moreover, there will be as many distinct fermentations brought about by one ferment as there are fermentable substances capable of supplying the carbon element of the food of that same ferment, in the same way that the equation of the nutrition of an animal will vary with the nature of the food which it consumes. As regards fermentation producing alcohol, which may be effected by several different ferments, there will be, in the case of a given sugar, as many general equations as there are ferments, whether they be ferment-cells properly so called, or cells of the organs of living beings functioning as ferments. In the same way the equation of nutrition varies in the case of different animals nourished on the same food, and it is from the same reason that ordinary wort produces such a variety of beers when treated with the numerous alcoholic ferments which we have described. These remarks are applicable to all ferments alike: for instance, butyric ferment is capable of producing a host of distinct fermentations, in consequence of its ability to derive the carbonaceous part of its food from very different substances, from sugar, or lactic acid, or glycerine, or mannite, and many others. When we say that every fermentation has its own peculiar ferment, it must be understood that we are speaking of the fermentation considered as a whole, including all the accessory products. We do not mean to imply that the ferment in question is not capable of acting on some other fermentable substance, and giving rise to fermentation of a very different kind. Moreover, it is quite erroneous to suppose that the presence of a single one of the products of a fermentation implies the co-existence of a particular ferment. If, for example, we find alcohol among the products of a fermentation, or even alcohol and carbonic-acid gas together, this does not prove that the ferment must be an alcoholic ferment, belonging to alcoholic fermentations, in the strict sense of the term, nor again does the mere presence of lactic acid necessarily imply the presence of lactic ferment. As a matter of fact,

different fermentations may give rise to one or even several identical products."

From this statement of the physiological conditions that modify the products of fermentation, it must be seen that uniformity in the quality of ensilage can only be secured by preventing fermentation altogether, or confining it within the narrowest possible limits. This can only be done by killing the bacteria of fermentation in the earliest stages of their activity, which would result in the production of ensilage free from acidity, and closely resembling, in quality, the green fodder from which it is made. If the bacteria can be killed, when the silo is covered and weighted, the inclosed mass of ensilage will be practically preserved under the same conditions as fruits, or vegetables, or meats, are preserved when canned.

The practical question, then, presents itself as to how this can best be accomplished. An extended series of observations on the samples of ensilage from the experimental silo have already been made, to determine the temperature required to kill the bacteria which cause the acid fermentations. This will, undoubtedly, vary somewhat with the kind of produce under treatment, and its condition when put in the silo. Thus far my experiments seem to indicate that a temperature of from 115° to 122°, maintained for one or two hours, will be sufficient to kill the bacteria under the conditions in which they are now placed. In this connection attention must be called to the fact that the time of exposure to a given temperature is quite as important as the temperature itself. A given temperature, continued for several days, may have a better effect than a higher one maintained but a few minutes. Again, a degree of heat that will kill the mature and active bacteria will not, in all probability, kill the germs which may produce succeeding generations of active bacteria if the given temperature is continued but a short time.

From the results recorded in the table, it is reasonable to infer that an initial temperature sufficiently high to kill the active bacteria would be continued for several weeks, and this, in all probability, would insure the destruction of any successive generations of bacteria that might be produced from the germs that had not been killed. For this purpose, silos with walls of wood may have an important advantage over those constructed of materials that are better conductors of heat.

In filling the silo, all writers on ensilage agree in giving directions which are based on Liebig's chemical theory of fermentation. The thorough packing of the ensilage as it is put in and the rapid filling of the silo are points that are strongly urged to prevent, as far as possible, the exposure of the fodder to the oxygen of the atmosphere, which is assumed to be the exciting cause of fermentation. In the light of the physiological theory of fermentation it will, however, be readily seen that the living ferments, which produce acidity, are

buried with the fodder as it is packed in the silo, and the exclusion of the atmosphere, as Pasteur has proved, is a condition that favors fermentation, the oxygen itself not being directly concerned in the process. When the greatest care is taken in packing the ensilage, the temperature of the mass will often rise above 100° Fahr. (I have observed a temperature of 105° under such conditions); and, when the time of filling is extended over several days, a considerably higher temperature may be developed.

There are good reasons for the belief that, with less packing of the fodder when put in the silo, the time of filling may be safely extended until the temperature rises to a point that is fatal to the bacteria, and this is the probable explanation of the reported cases in which the ensilage is said to be "sweet," or free from acidity.

The efficient cause of this preliminary heating process, or the changes in the fodder involved in its development, have not been determined by experiment, and we do not know the precise conditions under which the best results may be obtained.

In the present state of our knowledge of the subject, the most desirable method may be to fill the silo without any packing, beyond that produced by the weight of the superincumbent mass, and then allow it to remain until the desired temperature is reached, before putting on the cover and weights. The best method can only be determined by carefully conducted experiments, that are made with a full knowledge of the different conditions that may have an influence in modifying the results. It can not, however, be doubted that sour ensilage can only be produced by conducting the process so that the temperature does not rise above the point that is fatal to the bacteria (probably 115° to 120°).

Observations on temperature have been generally neglected when silos were filled, and we, therefore, lack the necessary data for determining the precise temperature required to prevent fermentation, or the most favorable conditions for producing it, from the results of practical experience.

Several cases have been reported to me in which the fodder at the time of filling the silo was supposed to be "spoiled" from the high temperature developed before it was covered and weighted, but on opening these silos, after several months, the result uniformly obtained was ensilage of the best quality, free from acidity. But a single case has, however, come to my knowledge, in which the exact temperature was recorded at the time of filling the silo, when the resulting product was *sweet* ensilage. Mr. George Fry, of England, reports the results of his experience the past season, which is of particular interest in connection with my experiments with ensilage. He filled a silo with *Trifolium incarnatum* (crimson clover), "rough grass," and "clover and rye grass," between the 7th and 30th of June, the temperature recorded at the time of covering being 132° six feet from the

surface. The cover was weighted with twelve inches of sand. On July 11th, and again on the 17th, the cover was taken off, and the silo was filled with "meadow-grass," to make up for the loss in settling. The temperature observed at these dates was 140° at a depth of six feet. In another silo, filled with clover and "rye-grass" and "meadow-grass," between June 30th and July 11th, when the cover was put on and weighted, the recorded temperatures were (July 7th) 149° and (July 14th) 158°. The first-mentioned silo was opened October 25th, and the ensilage is described as "of a brown color, and of a sweet, luscious odor, *free from acidity*, very much resembling that of ordinary hay," and it was at once eaten by cattle, sheep, and horses, with apparent relish.

Mr. James Chaffee, of Wassaic, New York, informed me that from unavoidable delays in filling his silo with fodder-corn, in 1882, the ensilage became so "hot," before it was covered and weighted, that he feared it would be entirely spoiled; but, when it was opened in the fall, the fodder was perfectly preserved, of a brown color, and sweet, delicious odor, without the slightest indication of acidity. His cows ate it with such a decided relish that he had no hesitation in saying it was the best ensilage he had ever made. Last year he followed the usual method of rapid filling and thorough packing, and his ensilage, when opened, was very sour, and in quality decidedly inferior to that made in 1882. Other cases of a similar import might be given to show that a temperature sufficiently high to kill the bacteria and prevent fermentation can readily be obtained in the process of filling the silo, and that the ensilage under such conditions is of much better quality than when the temperature is kept within the range that is favorable for the development of the acid ferments.

Experiments are now needed to determine the exact temperatures required for destroying the organisms that cause fermentation, under the different conditions presented at the time of filling the silo, and the special methods of practice that may be desirable in the treatment of different crops. This field of experimental investigation is of the greatest practical interest, and we may safely predict that the thermometer will soon be found as indispensable in securing the best results in the ensilage of green fodder as it is now in the various processes of the dairy.

GEOGRAPHY AND THE RAILROADS.

By Dr. J. JASTROW.

IT should be regarded as a prominent purpose, in any scientific description of the earth, to point out how geographical influences have impressed their mark on organic and inorganic nature and in the field of human civilization. Alexander von Humboldt set an admi-

rable example of the manner in which this should be done when he studied the relations existing between the geographical structure and the vegetation of different regions. Remarks upon the influence of soil and climate on plant-life are as old as the study of botany itself, but a scientific plant-geography has been developed only since Humboldt took the subject up. It has been followed by the study, upon similar principles, of geographical influences on animal life; and since Carl Ritter's time the diversified aspects of human civilization have been subjects of unceasing study from similar points of view. In this study, religious ideas, personal, civil, and legal rights, customs, and all the features of social and political life have been examined with reference to the influence of geographical conditions in shaping and modifying them. At first sight the management of railroads would seem to be one of the least amenable of all subjects to this method of consideration. Originating and brought to a considerable degree of perfection in England, the railroad system has been transplanted bodily into other countries, without considering any modifications of its methods necessary except in obedience to the most imperative exceptional physical requisitions. Yet modifications and individual differences of character have been impressed upon the railroad service of different countries by the silent working of varying geographical conditions. These differentiations were especially studied by the late Max Maria von Weber, whose theories respecting them are expounded in a posthumous work recently published in Berlin, in which he has considered the subject under the headings of the "Geography of Railroad Life" and the "Physiognomical Aspects of the Railroad Systems of Different Civilized Nations."

We may in the first place regard the manner in which the function and service of the railroad system are dependent upon the form and relations of a country's boundaries. The construction of the railways in insular countries is governed wholly by mercantile considerations, while, in countries whose boundaries are exposed, military and political objects claim prominence. Thus, an English railway-map affords a most accurate picture of the relations of the country to production and trade, and of the office of the railroads as the medium of communication between the great coal and iron fields on one side and the world's mart on the Thames on the other side. But the ramifications of the German system would be incomprehensible to one who did not consider that, equally with mercantile requirements, the political interests of a congeries of small states, the central situation of the empire among a number of jealous and ambitious powers, and the great military deficiency of the absence of a natural eastern boundary, have exerted a dominant influence in its arrangement. The clearly mercantile features of the organization of the railroads in states whose natural boundaries give them security are thus neither more nor less appropriate than the military and administrative methods prevalent in states

whose political integrity is precarious; and we have, in the degree to which additional defensive resources are needed, the first element of individualization according to geographical conditions.

The shape and extension, though the most obvious, constitute only one of the features in which the railroad system is affected by geographical conditions. Regarding the lines in the mercantile aspect, we find that the relative importance of their freight and passenger traffic is likewise subject to such influences. While in Germany freight is the all-important element in estimating the value of the business done by the railroads, and it would be thought folly to depend chiefly on the receipts from passengers, this is not the case in all countries. Herr von Weber gives a table of the relative value of the passenger and freight business of six countries, from which the results are deduced that in Austria it is as 1 to 4; in Russia, as 1 to 3·2; in Prussia, as 1 to 2·7; in England, as 1 to 1·3; in Italy, as 1 to 0·9; and in Denmark, as 1 to 0·5. In the first three countries here named, the excess is very largely in favor of the freight traffic; in England, the values of the two kinds are more nearly equal, while in Italy and Denmark the excess is on the side of the passenger traffic. The first three countries are continental, the last three are maritime. Where there are abundant water-ways to compete with the railroads, the freight, which seeks the easiest routes, goes to them, and the railroads have to rely more largely upon passengers; where water-ways are more rare, as on the great Continental plains, the freight is of necessity carried on the railroads, and they find in it the source of their most lucrative business, by the side of which the passenger traffic may sink into relative insignificance.

With equal acumen Herr von Weber has remarked a differentiation in conformity to geographical diversities in the means and apparatus which railroads employ in the performance of their work. At first sight it would appear that the wagons in which the goods are carried, which to-day are found on the Atlantic coast and in a few days more are removed to the borders of Asia, which in going scale Alpine ridges, and are before long to be returned to the ocean on routes passing through and under the mountains by tunnels, should be of uniform construction. Herr von Weber divides the equipment and appurtenances of a railway line into two groups, the first of which includes those articles that are stationary or which circulate only within a limited area, and the second those that are liable to be moved over the whole circuit of an extensive and complicated system. To the former class, of fixed elements, he assigns the road-bed and superstructure and all their accessories; to the other class, or that of movable properties, belong the wagons. Between the two classes are the locomotives, which only rarely go outside of the particular system to which they belong. "While the fixed organs," he says, "answer their purposes the more completely the more exactly they are adapted in indi-

vidual character to the conditions of the place, the movable properties are more serviceable in proportion as they are constructed so as to be susceptible of a more general adaptation." The former elements are wholly subject to the influence of geographical conditions, and are conformed to the diversities of provincial and even of local circumstances and requirements; the latter set particular geographical conditions at defiance, and only do homage to them at the line which separates districts between which no direct intercourse by railway exists. On the East Prussian bogs sleepers will be required of a different character from those which may be used on the sands of the marches; French locomotives are different in structure and performance from those used in Germany. But the freight-wagons are the same over the whole Continent; and it is only after crossing the ocean that the question of adapting the rolling stock to different conditions becomes a living one.

The following out of these principles in their particular applications would carry us too deeply into details. A single example of the manner in which local conditions may rule can be drawn from the history of early railway-building in the United States. Here "were made in incredible haste those lines that stretch toward the West, over extensive tracts of wild land, plains, river-bottoms, and prairies, pushing through the forest which afforded the principal part of the material for their construction. Thus arose, as the direct result of local conditions, that method of construction the rapidity and temporary character of which received the specific name of 'American.' The substructure was hastily thrown up, a rude mass of loose earth and rarely well ballasted, while the superstructure was built with long stringers of wood which in the scarcity of iron could be armored with only a thin, flat strap-rail. With a superabundance of wood, extensive depressions of the ground were crossed with trestle-work instead of embankments; the excellent quality of the wood permitted the rapid erection of high, broad-spanned wooden bridges; and the forest also furnished the material for the construction of wooden station-houses, water-stations, turn-tables, and everything else that could be made of that material." Now, with the growing scarcity of wood, and abundance of iron and steel, and the greater facility of transportation afforded by the railroads themselves—heavy steel rails, firm embankments, iron and stone bridges, and more substantial buildings, are taking the place of the former flimsy structures, and the "American" type of railway-structure as above described has nearly become a thing of the past.

Still, having the earlier American railroads in view, Herr von Weber shows that the solid wagons of European construction could not be trusted to the insecure foundations of these imperfectly finished tracks. The stiff carriages must be made more flexible, and thus originated the adjustable trucks of the American cars and locomotive. The

locomotive was furnished with an armor in the shape of the raking cow-catcher or the plow-shaped pilot to remove from the track logs, cattle, or whatever else might be found upon it; with a head-light to illuminate the track; with a bell to give warning at road-crossings and places where the public were exposed to danger; and with a spark-catcher, required by the former universal use of wood as fuel for the furnace. In this manner the physiognomy of the American locomotive was the outgrowth of the novel physical and geographical conditions of the new continent.

With these and other studies conducted in a similar spirit, of the problems which the geographical configuration of each country imposes upon its railway service, and the means which it permits or indicates for attaining a solution of them, Herr von Weber has undertaken to lay a scientific basis for his observations on the physiognomy of the railway systems among the principal civilized nations. He also offers some remarks on the special aspects of the service in different states; and in this category he has not omitted to indicate a geographical influence in points the determination of which would be regarded as wholly casual were not the evidence on the other side so strong. The traveler on the English railways must have remarked the quiet and self-sufficient manner in which every person, from the train-master, or conductor, to the porter, performs his duties; it is pleasant to have these observations not only confirmed but also shown to be the sign of just that which ought to be, by a writer who is an authority on the art of traveling. The English railway service owes its "physiognomy" to two circumstances: first, to the fact that England is the native country of the railway, in which the very people among whom the new institution grew up were intrusted with its working, and furnished a personal service "to the manor born"; and, secondly, to the purely mercantile character which, by the natural features and situation of the island, the railway administration is able to maintain. The business at an English railway-station is done in the same style as in an old mercantile house, where, instead of special directions having to be given all the time, it is understood by every one that he knows what his duties are and how he is expected to perform them. The case is different in Germany, where the railway system was transplanted already made, and it was necessary to create a personal service, and where the configuration of the boundaries had its influence, not only on the laying out of the lines, but also on the whole system of administration. It would not have been possible to secure certainty in the management if there had not been at hand a host of officers trained under military discipline, who, unqualified to act freely, knew well how to obey. An English engineer has described as the basis of the German service intelligent command and strict obedience. English management expects its subordinates to be intelligent enough to do the right thing without a special order. "If we should charac-

terize 'intelligent self-reliance' as the genius of the English system, 'organized instruction' of the French, and 'skillful daring' of the American, that of the German is unquestionably exact discipline."

Herr von Weber brings out many other features in illustration of his theory, and, without assuming that he has made even an approach to exhausting the subject, summarizes his conclusions in the remark that "the railway system of every region having distinctly marked geographical characteristics appears to be a product of its physical structure, soil, and climate, just as its flora and fauna, except that man has stepped in as an intervening agent between the natural conditions and their product. At some future period, when railways shall have spread over the whole earth, account will be taken in the particular adaptation of the new institutions of yet more widely differing and more distinctly marked geographical conditions, and the forms they assume will become so diversified that we shall be able to speak of the "geography of railway-life as we now speak of the geography of the animal-world and of the plant-world."—*Translated for the Popular Science Monthly from Das Ausland.*

THE LIFE-WORK OF PASTEUR.*

By HIS SON-IN-LAW.

LOUIS PASTEUR passed his childhood in a small tannery which his father had bought in the city of Arbois, in the department of the Jura, to which he removed from the ancient city of Dôle, in the same department, where he was born. When Louis became of suitable age, he was sent to the communal school, and was so proud of the fact that, though he was the smallest of the pupils, he went on the first day with his arms full of dictionaries away beyond his years. He does not appear, as yet, to have been a particularly diligent student. He was as likely to be found drawing a portrait or a sketch—and the walls of several Arboisian houses bear testimonies of his skill in this art—as studying his lesson, and to go a-hunting or a-fishing as to take the direct way to the school. Yet the principal of the college was ready to predict that it was no small school like this one, but some great royal institution, that was destined to enjoy his services as a professor. As there was no Professor of Philosophy in the college at Arbois, young Pasteur went to Besançon to continue his studies. Here, in the chemistry-class, he so vexed Professor Darlay with his frequent and searching questions, that the

* From a volume under this title, translated from the French by Lady Claude Hamilton. In press of D. Appleton & Co. The present article is translated and abridged directly from the French by W. H. Larrabee.

old gentleman was disconcerted, and declared it was his business to question the pupil, not Pasteur's to question him. Pasteur then had recourse to a pharmacist in the town who had gained some distinction in science, and took private lessons in chemistry from him. He fared better at the École Normale, where he had Balard for a teacher, and also enjoyed the instructions of Dumas, with whom he formed a life-long friendship at the Sorbonne.

Pasteur's first important investigation was suggested at about this time, by an observation of Mitscherlich, the German mineralogist, of a difference in the behavior toward polarized light of the crystals of paratartrate of soda and ammonia and tartrate of soda and ammonia, bodies identical in composition and external form and other properties. Pasteur discovered differences in the form of the crystals and the molecular structure of the two bodies that had escaped detection, and was led to consider that all things may be divided into two categories: those having a plane of symmetry—that is, capable of being divided so that the parts on either side of the plane of division shall be equal and identical—or symmetrical bodies; and dissymmetrical bodies, or those not capable of being so divided. Occupied with the idea that symmetry or dissymmetry in the molecular arrangement of any chemical substance must be manifested in all its properties capable of showing the quality, he pursued his investigations till he reached the conclusion that an essential difference in properties as to symmetry exists between mineral and dead matter and matter in which life is in course of development, the former being symmetrical, the latter unsymmetrical.

Pasteur's wedding-day came on while he was engaged in this investigation. He went, not to the marriage-feast, but to his laboratory, and had to be sent for when all was ready.

With his observing powers quickened by his studies of symmetry and dissymmetry, Pasteur went to the researches with which his life has been identified, beginning with his studies in fermentation. Liebig's theory, that fermentation is a change undergone by nitrogenous substances under the influence of the oxygen of the air, ruled at the time, and the observations of Schwann and Cagniard-Latour on the yeast-plant were overlooked or regarded as exceptional. M. Pasteur continued the investigation of the alcohol-producing yeast-plant, and, cultivating it in suitable solutions, proved that it possessed organizing power ample to account for the phenomena. He found a similar organism—minute cells or articulations narrowly contracted in the middle—active in the lactic fermentation, capable of cultivation; and another organism, a vibrion, full of motion, living singly or in chains, working in the butyric fermentation.

The butyric vibrion was found to work quite as vigorously and with as much effect when no air was added to the decoctions, and in fact to perish with a stoppage of the formation of butyric acid when air was

too freely supplied. Reverting to the development of the yeast-plant and the alcoholic fermentation, he found that they also went on best when free air was excluded. Thus, Liebig's dictum, that fermentation is the result of the action of oxygen, must be reversed or abandoned. The organisms working these processes were given the class-name of *anærobes*, or beings that live without air. The French Academy's impressions of the results of Pasteur's work were spoken by Dumas, who said to him, "In the infinitely little of life you have discovered a third kingdom to which belong those beings which, with all the prerogatives of animal life, have no need of air to live, and find the heat they require in the chemical decompositions they provoke around them." The place of the organisms in the economy of Nature had not yet been fixed, but Pasteur was able to declare: "Whether the progress of science makes the vibrion a plant or an animal, is no matter; it is a living being endowed with motion, that lives without air and is ferment." It would be mere repetition to follow the experiments in putrefaction, where Liebig had denied that living organisms have any place, into which Pasteur carried the same methods and obtained the same results as in the case of fermentation. He proved that living organisms have all to do with it.

After M. Pasteur had been collecting his proofs for twenty years, Dr. Bouillaud sharply asked in the Academy: "How are your microscopic organisms disposed of? What are the ferments of the ferments?" He, as well as Liebig, believed the question could not be answered. Pasteur proved, by a series of the parallel experiments of the kind that have since become familiar, that oxygen deprived of its germs is incapable of producing fermentation or putrefaction, even after years, while the same substances are acted upon at once if the germs are present; and then answered that the ferments are destroyed by a new series of organisms—*ærobes*—living in the air, and these by other ærobes in succession, until the ultimate products are oxidized. "Thus, in the destruction of what has lived, all is reduced to the simultaneous action of the three great natural phenomena—fermentation, putrefaction, and slow combustion. A living being, animal or plant, or the *débris* of either, having just died, is exposed to the air. The life that has abandoned it is succeeded by life under other forms. In the superficial parts accessible to the air, the germs of the infinitely little ærobes flourish and multiply. The carbon, hydrogen, and nitrogen of the organic matter are transformed, by the oxygen of the air and under the vital activity of the ærobes, into carbonic acid, the vapor of water, and ammonia. The combustion continues as long as organic matter and air are present together. At the same time the superficial combustion is going on, fermentation and putrefaction are performing their work, in the midst of the mass, by means of the developed germs of the anærobes, which not only do not need oxygen to live, but which oxygen causes to perish. Gradually the phenomena

of destruction are at last accomplished through the work of latent fermentation and slow combustion. Whatever animal or vegetable matter is in the open air or under the ground, which is always more or less impregnated with air, finally disappears. The processes can be stopped only under an extremely low temperature, . . . in which the microscopic organisms can not flourish. These facts come in to fortify the still new ideas of the part which the infinitely little play as masters of the world. If their work, always latent, were suppressed, the surface of the globe, overloaded with organic matters, would become uninhabitable."

Pasteur extended his observations to the acetic fermentation, or conversion of alcohol into vinegar, in which he found an organism, the *Mycoderma aceti*, actively promoting a process of oxidation. Liebig had attributed this fermentation, also, to the presence of an albuminoid body in process of alteration, and capable of fixing oxygen. He knew of the plant called "mother," but regarded it as an outgrowth of the fermentation, and in no sense the cause. Pasteur proved, by experiments that left no room for doubt—the prominent characteristic feature in all his investigations—that the plant is the real agent in producing the fermentation. He eliminated from his compositions the albuminoid matter, which Liebig had declared to be the active agent, and replaced it with crystallizable salts, alkaline phosphates, and earths; then, having added alcoholized water, slightly acidulated with acetic acid, he saw the mycoderm develop, and the alcohol change into vinegar. Having tried his experiments in the vinegar-factories at Orleans, he became so sure of his position that he offered to the Academy, in one of its discussions, to cover with the mycoderm, within twenty-four hours, from a few hardly-visible sowings, a surface of vinous liquid as extensive as the hall in which they were meeting.

Liebig allowed ten years to pass after Pasteur's investigations, and then published a long memoir traversing his conclusions. Pasteur visited Liebig at Munich, in 1870, to discuss the matter with him. The German chemist received him courteously, but excused himself from the discussion, on the ground of a recent illness. The Franco-German War came on; but, as soon as it was over, Pasteur invited Liebig to choose a committee of the Academy, and furnish a sugared mineral liqnid. He would produce in it, before them all, an alcoholic fermentation in such a way as to establish his own theory and contradict Liebig's. Liebig had referred to the process of preparing vinegar by passing diluted alcohol through wooden chips, as one in which no trace of a mycoderm could be found, but in which the chips appeared perfectly clean after each operation. It was, in fact, impossible that there should be any mycoderm, because there was nothing on which it could be fed. Pasteur replied to this: "You do not take account of the character of the water with which the alcohol is diluted. Like all common waters, even the purest, it contains ammoniacal salts and

mineral matters that can feed the plant, as I have directly demonstrated. You have, moreover, not carefully examined the surface of the chips with the microscope. If you had, you would have seen the little articles of the *Mycoderma aceti*, sometimes joined into an extremely thin pellicle that may be lifted off. If you will send me some chips from the factory at Munich, selected by yourself in the presence of its director, I will, after drying them quickly in a stove, show the mycoderm on their surface to a committee of the Academy charged with the determination of this debate." Liebig did not accept the challenge, but the question involved has been decided.

The experiments in fermentation led by natural steps to the debate on spontaneous generation, in which Pasteur was destined to settle a question that had interested men ever since they lived. The theory that life originates spontaneously from dead matter had strong advocates, among the most earnest of whom was M. Pouchet. He made a very clear presentment of the question at issue, saying: "The adversaries of spontaneous generation assume that the germs of microscopic beings exist in the air and are carried by it to considerable distances. Well! what will they say if I succeed in producing a generation of organized beings after an artificial air has been substituted for that of the atmosphere?" Then he proceeded with an experiment in which all his materials and vessels seemed to have been cleansed of all germs that might possibly have existed in them. In eight days a mold appeared in the infusion, which had been put boiling-hot into the boiling-hot medium. "Where did the mold come from," asked M. Pouchet, triumphantly, "if it was not spontaneously developed?" "Yes," said M. Pasteur, in the presence of an enthusiastic audience, for Paris had become greatly excited on the subject, "the experiment has been performed in an irreproachable manner as to all the points that have attracted the attention of the author; but I will show that there is one cause of error that M. Pouchet has not perceived, that he has not thought of, and no one else has thought of, which makes his experiment wholly illusory. He used mercury in his tub, without purifying it, and I will show that that was capable of collecting dust from the air and introducing it to his apparatus." Then he let a beam of light into the darkened room, and showed the air full of floating dust. He showed that the mercury had been exposed to atmospheric dust ever since it came from the mine, and was so impregnated and covered with it as to be liable to soil everything with which it came in contact. He instituted experiments similar to those of M. Pouchet, but with all the causes of error that had escaped him removed, and no life appeared. The debate, which continued through many months, and was diversified by a variety of experiments and counter-experiments, was marked by a number of dramatic passages and drew the attention of the world. M. Pasteur detected a flaw in every one of M. Pouchet's successful experiments, and followed each one with a more exact experiment of his

own, which was a triumph for his position. Having shown, by means of bottles of air collected from different heights in a mountain-region, that the number of germs in the air diminishes with the elevation above the earth, and that air can be got free from germs and unproductive, M. Pasteur asserted decisively: "There is no circumstance now known that permits us to affirm that microscopic beings have come into the world without germs, without parents like themselves. Those who affirm it have been victims of illusions, of experiments badly made, and infected with errors which they have not been able to perceive or avoid. Spontaneous generation is a chimera." M. Flourens, Perpetual Secretary of the Academy, said: "The experiments are decisive. To have animalcules, what is necessary, if spontaneous generation is real? Air and putrescible liquids. Now, M. Pasteur brings air and putrescible liquids together, and nothing comes of it. Spontaneous generation, then, is not. To doubt still is not to comprehend the question." There were, however, some who still doubted, and to satisfy them M. Pasteur offered, as a final test, to show that it was possible to secure, at any point, a bottle of air containing no germs, which would, consequently, give no life. The Academy's committee approved the proposition; but M. Pouchet and his friends pleaded for delay, and finally retired from the contest.

The silk-raising industry of the south of France was threatened with ruin by a disease that was destroying the silk-worms, killing them in the egg, or at a later stage of growth. Eggs, free from the disease, were imported from other countries. The first brood flourished, but the next one usually fell victims to the infection, and the malady spread. All usual efforts to prevent it or detect its cause having failed, a commission was appointed to make special investigations, and M. Pasteur was asked to direct them personally. He did not wish to undertake the work, because it would withdraw him from his studies of the ferments. He, moreover, had never had anything to do with silk-worms. "So much the better," said Dumas. "You know nothing about the matter, and have no ideas to interfere with those which your observations will suggest." Theories were abundant, but the most recent and best authorities agreed that the diseased worms were beset by corpuscles, visible only under the microscope. He began his investigations with the idea that these corpuscles were connected with the disease, although assurances were not wanting that they also existed in a normal condition of the silk-worm. M. Pasteur's wife and daughters, and his assistants in the normal school, associated themselves with him in the studies, and became, for the time, amateur silk-raisers. He studied the worms in every condition, and the corpuscles in every relation, for five years. He found that there were two diseases—the contagious, deadly *pébrine*, the work of the corpuscles, and *flachery*, produced by an internal organism; and "became so well acquainted with the causes of the trouble and their different manifestations that he could, at will,

give *pébrine* or *flachery*. He became able to graduate the intensity of the disease, and make it appear at any day and almost at any hour." He found the means of preventing the disorders, and "restored its wealth to the desolated silk district." The cost of this precious result was a paralysis of the left side, from which he has never fully recovered.

As early as 1860 M. Pasteur expressed the hope that he might "be able to pursue his investigations far enough to prepare the way for a more profound study of the origin of diseases." Reviewing, at the conclusion of his "Studies on Beer," the principles which had directed his labors for twenty years, he wrote that the etiology of contagious diseases was, perhaps, on the eve of receiving an unexpected light. Robert Boyle had said that thorough understanding of the nature of fermentations and ferments might give the key to the explanation of many morbid phenomena. The German doctor, Traube, had in 1864 explained the ammoniacal fermentation of urine, by reference to Pasteur's theory. The English surgeon, Dr. Lister, wrote in 1874 to Pasteur that he owed to him the idea of the antiseptic treatment of wounds which he had been practicing since 1865. Professor Tyndall wrote to him, in 1876, after having read his investigations for the second time: "For the first time in the history of science we have a right to entertain the sure and certain hope that, as to epidemic diseases, medicine will shortly be delivered from empiricism and placed upon a really scientific basis. When that great day shall come, mankind will, in my opinion, recognize that it is to you that the greatest part of its gratitude is due."

The domestic animals of France and other countries had been subject to a carbuncular disease, like the malignant pustule of man, which took different forms and had different names in different species, but was evidently the same in nature. A medical commission had, between 1849 and 1852, made an investigation of it and found it transmissible by inoculation from animal to animal. Drs. Davaine and Rayer had, at the same time, found in the blood of the diseased animals minute filiform bodies, to which they paid no further attention for thirteen years, or till after Pasteur's observations on fermentation had been widely spread. Then, Davaine concluded that these corpuscles were the source of the disease. He was contradicted by MM. Jaillard and Leplat, who had inoculated various animals with matter procured from sheep and cows that had died of the disease without obtaining a development of the bodies in question. Davaine suggested that they had used the wrong matter, but they replied that they had obtained it direct from an unmistakable source. Their views were supported by the German Dr. Koch and M. Paul Bert. At this point, M. Pasteur stepped in and began experiments after methods which had served him as sure guides in his studies of twenty years. They were at once simple and delicate. "Did he wish, for example, to demonstrate that

the microbe-ferment of the butyric fermentation was also the agent in decomposition? He would prepare an artificial liquid, consisting of phosphate of potash, magnesia, and sulphate of ammonia, added to the solution of fermentable matter, and in the medium thus formed would develop the microbe-ferment from a pure sowing of it. The microbe would multiply and provoke fermentation. From this liquid he would pass to a second and then to a third fermentable solution of the same composition, and so on, and would find the butyric fermentation appearing in each successively. This method had been sovereign in his studies since 1857. He now proposed to isolate the microbe of blood infected with carbuncle, cultivate it in a pure state, and study its action on animals." As he was still suffering from a partial paralysis, he employed M. Joubert to assist him and share his honors. In April, 1877, he claimed before the Academy of Sciences that he had demonstrated, beyond the possibility of a reply, that the bacillus discovered by Davaine and Rayer in 1850 was in fact the only agent in producing the disease. It still remained to reconcile the facts adduced by Messrs. Jaillard and Leplat with this assertion. The animals which they had inoculated died, but no bacteria could be found in them. M. Paul Bert, in similar experiments, had found a disease to persist after all bacteria had been destroyed. An explanation of the discrepancy was soon found.

The bacteria of carbuncle are destroyed as soon as putrefaction sets in. The virus with which these gentlemen had experimented was taken from animals that had been dead twenty-four hours and had begun to putrefy. They had inoculated with putrefaction, and produced septicæmia instead of carbuncle. All the steps in this line of argument were established by irrefragable proof. M. Pasteur afterward had a similar controversy with some physicians of Turin, at the end of which they shrank from the test experiment he offered to go and make before them. "Remember," shortly afterward said a member of the Academy of Sciences to a member of the Academy of Medicine, who was going—in a scientific sense—to "choke" M. Pasteur, "M. Pasteur is never mistaken."

Having discovered and cultivated the microbe that produces hen-cholera, Pasteur turned his attention to the inquiry whether it would be possible to apply a vaccination to the prevention of these terrible diseases of domestic animals. He found that he could transplant the microbe of hen-cholera to an artificially prepared medium and cultivate it there, and transplant it and cultivate it again and again, to the hundredth or even the thousandth time, and it would retain its full strength—provided too long an interval was not allowed to elapse between the successive transplantations and cultures. But if several days or weeks or months passed without a renewal of the medium, the culture being all the time exposed to the action of oxygen, the infection gradually lost in intensity. A virus was produced of a strength

that would make sick, but not kill. Hens were inoculated with this, and then, after having recovered from its effects, with virus of full power. It made them sick, but they recovered. A preventive of hen-cholera had been found. In the experiments upon the feasibility of applying a similar remedy to carbuncular diseases, it was necessary to ascertain whether or not animals, which had once been stricken with the disease, were exempt from liability to a second attack. The investigator was met at once by the formidable difficulty that no animals were known to have recovered from a first attack, to serve as subjects for trial. A fortunate accident in the failure of another investigator's experiment gave M. Pasteur a few cows that had survived the disease. They were inoculated with virus of the strongest intensity, and were not affected. It was demonstrated, then, that the disease would not return. M. Pasteur now cultivated an attenuated carbuncle-virus, and, having satisfied himself that vaccination with it was effective, declared himself ready for a public test-experiment. Announcing his success to his friends, he exclaimed in patriotic self-forgetfulness, "I should never have been able to console myself, if such a discovery as I and my assistants have just made had not been a French discovery!"

Twenty-four sheep, a goat, and six cows were vaccinated, while twenty-five sheep and four cows were held in reserve, unvaccinated, for further experiment. After time had been given for the vaccination to produce its effect, all of the animals, sixty in number, were inoculated with undiluted virus. Forty-eight hours afterward, more than two hundred persons met in the pasture to witness the effect. Twenty-one of the unvaccinated sheep and the goat were dead, and two more of the sheep were dying, while the last one died the same evening; the unvaccinated cows were suffering severely from fever and œdema. The vaccinated sheep were all well and lively, and the vaccinated cows had neither tumor nor fever of any kind, and were feeding quietly. Vaccination is now employed regularly in French pastures; five hundred thousand cases of its application had been registered at the end of 1883; and the mortality from carbuncle has been reduced ten times.

There is no need to follow M. Pasteur in his further researches in the *rouget* of pork, in boils, in puerperal fever, in all of which, with other maladies, he has applied the same methods with the same exactness that have characterized all his work. His laboratory at the École Normale is a collection of animals to be experimented upon—mice, rabbits, Guinea-pigs, pigeons, and other suitable subjects, with the dogs upon which he is now studying hydrophobia most prominent. There is nothing cruel in his work. His inoculations are painless, except as the sickness they induce is a pain, and the suffering they cause is as nothing compared with that which they are destined to save. On this subject he himself has remarked in one of his lectures: "I could never

have courage to kill a bird in hunting; but, in making experiments, I have no such scruples. Science has a right to invoke the sovereignty of the end."

What he has done, M. Pasteur regards as only the beginning of what is to be accomplished in the same line. "You will see," he has sometimes said, "how this will grow as it goes on. Oh, if I only had time!"

CLEAN DRINKING-WATER.

By EDWIN J. HOWE, M. D.

AMONG the subjects that claim the study of the sanitarian, there is none that has a closer relation to public health, and hence none more worthy of careful investigation, than the water we drink. Receiving it, as we do, from varied sources—from spring, well, brook, or river—its character varies greatly; and, while in its purity bringing with it refreshment and health, in a polluted condition it too often carries in its wake disease and death.

The study of sanitary science during the last few years has demonstrated beyond a doubt that many severe epidemics have arisen from the use of impure water, as the reading of Witthaus, Parkes, Buck, Flint, Pavy, or other writers on the subject, will clearly prove.

When we remember that water has greater solvent properties than any other liquid known, we can readily understand how it often becomes such a disease-spreading medium. Besides carrying with it vegetable and organic impurities in suspension, it dissolves many of those that are the most subtile and dangerous to the human organism. The dangers of drinking impure water may best be presented in a few quotations from well-known authorities.

Pavy, in "Food and Dietetics," says: "Water has much to answer for in the causation of disease. . . . It" (polluted water) "is acknowledged to be one of the common causes of dysentery, and has been alleged, when derived from a marshy district, to be capable of inducing malarial fever and its concomitant, enlargement of the spleen. . . . Typhoid has been frequently communicated through the medium of water. Milk, adulterated with polluted water, has been the cause of serious outbreaks of fever." Parkes, in his "Manual of Practical Hygiene," shows that the baneful effects of polluted water were known to the ancient Greeks. Hippocrates, who was born 460 B. C., asserts, "The spleens of those who drink the water of marshes become enlarged and hard." Parkes considers typhoid, cholera, scarlet fever, and diphtheria, and some forms of skin-disease, "likely to be propagated by means of water."

Polluted water that has been frozen, though improved by the freezing, does not become innocuous. "Ice and snow may be the

means of conveying malarial poisons to places at a distance," by distributing organic matter held in suspension. Dr. Edwards, of Montreal, found two grains of organic matter to the gallon of melted shore-ice, and one grain to the gallon of river-ice. One writer, Pavy, says, "River water and the water of shallow wells should always be regarded with suspicion," and he adds, "There is evidence to show that the most serious consequences have arisen from the consumption of impure water." Buck, in "Hygiene and Public Health," says, "The weight of evidence and authority favors the idea that the drinking-water may become the cause of disease, and in drinking a polluted water one always runs more or less risk." The River Pollution Commission of London, after analyzing water from different sources, reported dangerous "river-water to which sewage gains access."

The conclusion from the above quotations is, not that one should abstain from drinking water on account of the difficulty in obtaining it pure, but that proper precautions should be observed to obtain it pure. Water is Nature's means of slaking thirst, and with its refreshing properties combines valuable therapeutic qualities.

An excellent article, published in the "Boston Journal of Chemistry," in treating of the curative value of water says: "We notice the salutary influence of water-drinking upon many of those who resort to the so-called mineral springs which abound in the country. It is not necessary that these springs should hold abnormal quantities of salts of any kind to effect cures; it is only necessary that the water should be pure. Ordinary springs, such as are found in every farmer's pasture, are curative springs if the waters are used freely by those who suffer from certain gastric or renal difficulties." This writer asserts that the best known of our Eastern mineral waters shows, on analysis, that its curative value consists solely in its purity.

It may be truthfully asserted that it is impossible to procure perfectly pure water. "Even distilled water and fresh rain-water contain some ammonia, carbonic acid, and other matters which detract from their purity; while the best water from rivers, wells, ponds, and tanks, contains a large number of chemical compounds, chiefly salts." The skillful use of the microscope would condemn the water from many sources for drinking purposes which now is considered pure. But while we can not obtain strictly pure water, even by distillation, we can obtain it so pure that it will meet our demands, and that without danger to the consumer's health. The means by which this may be accomplished is filtration.

A filter is an apparatus for separating from fluids the foreign substances mechanically intermixed with them and held in suspension. While this is all that most filters aim to accomplish, yet experiments show that a filtering material may be used which very markedly diminishes the foreign bodies usually held in solution in water, and also removes those held in suspension.

The devices that have been used and are now employed for filtering purposes are very numerous. Tracing their history from the old Hippocratic sleeve, which was a cone-shaped bag of cotton or wool, we find, among others, the following materials: Thick unsized paper; cloth of various texture; sand; asbestus; animal charcoal; vegetable charcoal; felt; porous stones of various kinds; spongy iron; porous earthenware; perforated metallic disks; sponge; carferal, a composition consisting of a mixture of charcoal, iron, and clay; silicated carbon; ground slag, or compounds of two or more of these substances mentioned.

The essentials of a good filter for domestic purposes are—1. Efficiency in removing foreign bodies held in suspension. 2. Chemical power to destroy animal and vegetable impurities in solution or to convert them into innocuous substances. 3. Freedom from all possibility of tainting the water. 4. Simplicity of construction, so as to admit of the filtering material being readily renewed. 5. Cheapness. A good filter for domestic purposes must possess all five of these qualities. Those that have two or three of them and lack the remainder do not practically solve the problem of giving us clean water to drink.

The Japanese use a porous sandstone hollowed in the shape of an egg, through which the water percolates into a receptacle underneath; the Egyptians resort to a similar device; the Spaniards use a porous earthen pot. But these and other similar contrivances can not be thoroughly cleansed; after the most thorough rinsing, some impurities will remain in the pores of the stone. Spongy iron and carferal are open to the same objection; they will answer well for a short time, but soon become contaminated by pollution retained in their pores. Sponge, cloth, and felt, unless cleaned every day or two with hot water, will do more harm than good, and the average servant-girl will not clean them or any other filter unless under the eye of her mistress.

The various forms of filters that are screwed to the faucet have only to be hastily examined to be discarded, as there is not sufficient filtering material in them to be of much utility, and they very soon become foul and offensive. Buck says, "There is no material known which can be introduced into the small space of a tap-filter and accomplish any real purification of the water which passes through at the ordinary rate of flow."

The various complicated closed filters, filled with any material which can not be removed for cleansing, condemn themselves. No amount of pumping water through them at different angles, which is at all likely to be used, can cleanse them of the impurities that adhere to the mass and in the pores of the filtering material used. Parkes, in his "Manual of Practical Hygiene," says, "Filters, where the material is cemented up and can not be removed, ought to be abandoned altogether."

The various metal filters in which the water comes in contact with metallic surfaces, either iron, lead, tinned iron, or zinc, are objectionable from their appreciable influence upon the water retained in them for any considerable time. Pure block-tin is the least objectionable of any of the metals.

The aim of most filters is to remove impurities from the water speedily—as rapidly as it escapes from the faucet. Experiment shows that effective filtration can not be accomplished in this way, as the water does not remain long enough in contact with the filtering material used to become purified of much that might be removed by slow filtration or percolation through the same appliance. Of all the filtering materials mentioned, it seems to me that sand and charcoal are the two that accomplish the best results, and of these vegetable charcoal is the best.

Clean quartz sand will retard the passage of some impurities held in suspension, but no very careful investigation is necessary to demonstrate the presence of many impurities in water that has passed through it. The naked eye can detect them in most samples. Buck states, "The spores of algæ are not removed by the passage of water through sand," and he adds that "clean quartz sand can produce little effect" on polluted water. But he and many if not all other sanitarians assert that charcoal does purify the water and remove the odor of putrefaction. While there is no lack of authority to prove the value of animal charcoal as a filtering material, the claims of vegetable charcoal seem to me to make it more serviceable. Vegetable charcoal is "the solid residuum of the destructive distillation of wood." It is insipid and inodorous, it is insoluble in water, it is but little affected by either acids or alkalies. The ash consists chiefly of carbonate of potash, silica, lime, and the oxide of iron. Vegetable charcoal has a strong deodorizing power. Water containing sulphureted hydrogen speedily loses its odor when filtered through it. The taste of liquids, when dependent on the presence of certain organic substances, is almost or entirely removed by filtering through it. "The purifying, antiseptic power of charcoal is due to the action of its absorbed oxygen upon organic matter." A careful authority says: "Charcoal, by possessing the properties of absorption, decomposition, and combination, is eminently fitted as a filter for the purification of water, removing from it the color, odor and taste of its impurities by oxidizing and recombining them into other and inoffensive substances." A reference to chemistry shows us that the following gases are absorbed by charcoal: Hydrogen, nitrogen, carbonic oxide, marsh-gas, nitrous oxide, carbonic acid, olefiant gas, sulphurous acid, air, sulphureted hydrogen, muriatic acid, hydrochloric acid, and ammonia.

Witthaus, in his "General Medical Chemistry," says on this subject: "Its" [vegetable charcoal's] "power of absorbing odorous bodies renders it valuable as a disinfecting and filtering agent, and in the

prevention of putrefaction and fermentation of certain liquids. It is with this view that the interiors of barrels intended to hold wine, beer, or water, are carbonized. Certain odorous culinary operations are rendered inodorous by the introduction of a fragment of charcoal into the pot. The efficacy of charcoal as a filtering material is due in a great measure to the oxidizing action of the oxygen contained in its pores."

In the article on vegetable charcoal in the "National Dispensatory," the writer says: "The most fetid gases disengaged by putrefaction are among those which are the most abundantly absorbed by charcoal, viz., ammonia, sulphureted hydrogen, and sulphurous acid, and the oxygen contained in the charcoal combines with the other deleterious substances and generates new and inodorous compounds." Buck says, "All varieties of carbon formed by the destructive distillation of vegetable or animal matter possess the property of removing organic matter from solution." Fowne's "Chemistry" says of charcoal, "It is said to absorb ninety times its volume of ammonical gas." But sufficient authorities have been quoted to prove the high estimate in which vegetable charcoal is held as a filtering material by chemists and sanitarians. Careful experimenting with it has satisfied me of its efficacy and practicability. It is efficient, clean, easily obtained by any one, and so cheap that after a few weeks' use it can be thrown away, and a clean supply substituted, and the cost need not be taken into consideration. Animal charcoal possesses valuable filtering properties, but it is very expensive, difficult to be obtained, and is so associated in the minds of the people with dead horses and the bone-yard that a strong prejudice exists against it. I have thus tried to show in this paper—1. That clean drinking-water is essential to health. 2. Some of the well-established results of drinking polluted water. 3. The various filtering materials that have been used, with their merits and objections. 4. The superiority and availability of vegetable charcoal as a filtering material.

In conclusion, in answering the question, "How, then, may we obtain clean drinking-water?" I would answer, by filtering the water slowly through properly adjusted vegetable charcoal placed in an earthen receptacle of some kind so that the water will not come in contact at any stage of its passage through the filter with metal of any kind. Cool the filtered water by placing ice under or around the vessel in which the water is contained, but do not put the ice into the water, or its impurities will be liberated by melting and contaminate it. Acting on these suggestions, I believe clean drinking-water may be obtained in any family, and, with clean water, less sickness.

PHYSIOLOGY *VERSUS* METAPHYSICS.

By WALTER HAYLE WALSHE, M. D.

"The laboratory is the forecourt of the temple of Philosophy; and whoso has not offered sacrifices and undergone purification there, has little chance of admission into the sanctuary."—HUXLEY, "Life of Hume."

"It was the glory of Hippocrates to have brought Philosophy into Medicine, and Medicine into Philosophy."—AUCTOR (?).

"Attendre et espérer" (To wait and hope).—DUMAS, "Monte Cristo."

FEW physiologists, mixing in general society, can have failed to notice how common it is to hear their psychological brethren (if referred to at all) stigmatized as atheists; and this alike in coteries distinguished for pugnacious religious dogmatism, and in social circles where indifferentism marks the prevailing tone of thought. The acrimony with which the charge is made apparently increases, on the one hand, in the direct ratio of the bigotry or religious fervor, and, on the other, in the inverse ratio of the scientific enlightenment of different speakers. Furthermore, in certain cliques a shrewd suspicion seems to have arisen that, as any whole includes its parts, physiology in general (nay, even medical science at large) is chargeable with the delinquencies of its cerebral department, and is hence condemned by these judges as a representative in its entirety of atheistic proclivity and purpose. An illustration in point may be found in the columns of the leading daily journal, wherein the reviewer of the volumes of Bain, Bastian, and Luys on Mind, Body, and Brain, "need scarcely say that in all three works the physiological (some would say materialistic) aspects of the subject are strongly insisted upon."* No doubt some would say so, and thence at a bound jump to the conclusion (a foregone one with all who use the word "materialist" in an adverse sense) that all these authors are "atheists." In point of fact, the masses are hardly wiser in their estimate of medical belief than two centuries ago, when lay smartness and ignorance combined had fashioned the libelous apothegm, "*Ubi tres medici, ibi duo athei*" † (where three doctors are, there are two atheists).

Now, metaphysical psychologists, though inquiring as boldly from their point of view into the genesis of mind, have contrariwise, with rarest exceptions, escaped and continued to escape this form of social obloquy. Whence comes this diversity of judgment? Are physiologists thus penalized because they have shown that a certain definite, if subordinate, part is played by physics and chemistry in the complex act of evolving thought, and because they have thus, at least partially, succeeded in wrenching this branch of philosophy from the nerveless grasp of the pure introspectionist? Has the success of cerebral physi-

* The "Times," January 19, 1883.

† Browne, "Religio Medici."

ology in the surface-penetration of some of the secrets of thought-production led to its condemnation? Should those secrets, in obedience to theological casuistry, be allowed to linger on in primitive obscurity, as though the earnest use of our divinest gift, intellect, were not the most fitting and the most grateful form of homage to the all-bounteous Giver? If our science toils on in humble but trusting hope to fathom on material lines the mechanism of our mental operations, is its pursuit antagonistic to belief in an Almighty First Cause?* Is there really any fair ground for the inference, that because physiology strives to trace out and interpret the conditions of the connection between brain-substance and mind—*ergo*, those who labor in its field are of necessity atheists? The inquiries seem to deserve an answer. Let us, then, see to what the teachings of physiology in this direction really amount. Let us try to determine whether (conflicting though they may prove with the postulates of various narrow and sectarian systems of theology) those teachings really antagonize any formal or essential principle of deistic faith, whether, though confessedly open to the charge of "heresy" (that charge so dear to sacerdotalism),† they do not escape even the suspicion of that treason against nature, atheism?‡

We must prelude the inquiry into the direct work of physiology by a very rapid glance at the notions advanced by metaphysicians and theologians on the nature of mind and generation of thought. Our task throughout will be merely one of historical and very occasionally critical review. We lay no claim to originality of doctrine, but shall merely attempt in simple fashion to popularize knowledge, which, alike from its nature and from the manner of its handling, has been essentially limited to the few.

1. Now, metaphysicians (they who profess their ability to formulate an *a priori* theory of the ultimate elements of knowledge and nature of things) have held, as a class, that the act of thinking is in

* Blaise Pascal (1623–'62), philosopher of no mean grasp and honesty though he was, strove to dissuade his generation from following out the Copernican system to its issues because it maintained the heretical doctrine of the movement of the earth. Pascal would not have merited censure for hesitating to accept the Copernican system had he argued on supposed philosophic grounds (Milton died uncertain which to accept, the doctrine of Ptolemy or Copernicus); his grave error consists in having preferred theological *dogma* to that which he felt to be *truth*.

† "Heresy," aptly styled by Lanfrey, "Cette éternelle protestation de la liberté de l'esprit humain contre les doctrines infaillibles" (That eternal protest of liberty of the human mind against infallible doctrines). "Histoire Politique des Papes," p. 70: Ed. Charpentier.

‡ Atheist and atheism are words constantly used in total ignorance of their real meaning. An angry religionist, being asked for his definition of the term atheist, unhesitatingly replied, "I call any man an atheist who does not go to my church, or some one like it." Strong in sectarian conviction, but weak in classical attainment, my friend evidently had, like one greater than he, "small Latin and less Greek," and knew as little of etymology as he felt of toleration for any creed but his own. But was he not (setting aside the question of verbal roots) a fair specimen of a large class?

all its stages and all its factors a non-material process. And it does not involve any serious error to maintain that the formula under which this doctrine obtained the widest acceptance by philosophy, while it best satisfied the craving of ordinary people for some insight into the nature of their mental operations, originated with Descartes. And this philosopher's well-known formula assumed: there exists a spiritual, non-extended, indivisible substance, an objective, immortal entity, superadded to and independent of brain, which thinks, feels, and wills —a substance cognizable by self-consciousness alone, and which is in fact the "thinking principle" or proper "soul." Mind thus becomes absolutely and wholly an extra-cerebral product, and the possible offspring of activity on the part of the "soul" alone. The purely hypothetical character of this doctrine, the feeble, in some sense half-hearted, support given it by its originator, its incompatibility with every-day experiences of cerebral disease, and its proving a hopeless puzzle to cultured people, at once endowed with the critical faculty and unbiased by prejudice, all alike failed to shake its supremacy, and for long years it held sway, not as a makeshift, provisional, mere scholastic formula, but as an established primary truth. And all this, though Descartes himself, in the following words, honestly avowed his disbelief in the surety of his own doctrine: "Je confesse," he writes, "que par la seule raison naturelle nous pouvons faire beaucoup de *conjectures* sur l'âme et avoir de flatteuses espérances, *mais non pas aucune assurance*"* (I confess that by natural reason we can make many conjectures about the soul, and have flattering hopes, but no assurance).

Meanwhile, as mind was thus made a product of the soul, the question at once arose by necessary involution, What in turn was the soul? Now, in all probability, no more startling chapter figures in the history of philosophy than that chronicling the varied efforts made at furnishing a sufficing reply to this query. From the days of Plato to our own, metaphysicians seem to have lost themselves in a maze of conjectures, too often, unfortunately, no less dogmatic in tone than vague and unsatisfactory in essence. Yet be their failures, while unflinchingly registered, freely forgiven; the obscurity of the problem to be solved, coupled with the imperfection of the instrument selected for its solution, has ever proved an obstacle to success, even when that instrument has been handled by the deepest thinkers and most devoted searchers after truth.

Thus, setting aside the *profanum vulgus* of illogical and inaccurate writers, with whom the word is but a word, carrying with it no inkling even of definite signification, we find that with some philosophers

* In explanation of his doubtingness, we must remember Descartes was not merely a metaphysician—he was likewise a physicist of high distinction. The positive tendencies fostered by physical objective study served to counterbalance within certain limits the subjective transcendental activity of his grand intellect.

the soul is a local, with others a universal, existence; by some limited to man, by others conceded to the lower animals; with certain thinkers an essence, with others a substance, with a third group a principle; with some an immaterial essence without form or extension, with others immaterial, yet possessed of these attributes of matter; with the majority a simple, with the minority a compound, existence, and with a small fraction of the latter a tripartite body, of which each division is again subdivided into three; with this sect a something contained in the body, with that a something containing it; with Aristotle an equivalent of "all the functions, sentient and nutritive, of living bodies up to the highest attributes of intellect," the "rational soul" being especially seated in the heart;* with the Neo-Platonists an "image or product of reason," producing in turn the corporeal; with Descartes the "spiritual substance," or "principle" just referred to, provided with a habitat in the pineal gland, a home exchanged by others for the ventricles, the corpora striata, the white substance of the hemispheres, their cortex, the plexus choroides, the dura mater, the heart, and the blood; with Locke a spiritual essence or a material substance—he could not "fixedly determine" which; with certain philosophers a something pre-existent from all time, with others evolved *pari passu* with the organism it inhabits; in the opinion of one group of school-men perishing with the associated body, in that of a second wholly immortal, in that of a third mortal in the main, but in one of its parts immortal. Further, philosophers who maintained each soul was formed specially for its own individual organism, varied in all conceivable ways as to the time and place of union of the two, while the parallel difficulty followed in settling the precise moment of somatic death at which separation of the two must occur.†

The vast majority of these speculators recoiled from the pre-

* Prochaska, "Nervous System," quoted by Bastian, "The Brain as an Organ of Mind," p. 511. On the contrary, according to the shrewder insight of one of the most far-seeing of physiologists, Xavier Bichat, the heart, or its vicinity, holds relationship to the *passions*, the head to *intellectual* phenomena. "L'acteur," he says, "qui ferait une équivoque à cet égard, qui, en parlant de chagrins rapporterait les gestes à la tête, ou les concentrerait sur le cœur pour annoncer un effort de génie se couvrirait d'un ridicule, que nous sentirions mieux encore que nous le comprendrions" (The actor who should make a mistake in this matter, who, speaking of his griefs, should refer his gestures to his head, and who should concentrate them upon his heart in announcing an intellectual effort, would cover himself with a ridicule that we can feel better than we can comprehend).—"Vie et Mort," p. 42, Paris, 1813.

† Singularly enough, this speculative difficulty has occasionally proved the source of specific practical inconvenience. Thus "Turkish graves are very shallow, sometimes not more than a foot in depth, the reason for this being that most old-fashioned Turks still retain the superstition that the soul does not leave the body until some time after burial, when it is drawn from the grave by the angel of death, who would find great difficulty in performing his task if the body was too deeply buried. The consequence of this is that in warm weather a horrible stench arises from the cemeteries."—"God's Acre Beautiful," by W. Robinson, F. L. S, p. 117.

sumptuous task of attempting to define the actual composition of the soul, a few only of the most wildly transcendental satisfying themselves that it consisted of "a drop of ether," of a "globule or spark of heat or light," of an "animated vapor," etc.

Not more widely divergent than the metaphysical notions of the nature of soul were the doctrines held as to the manner of intercourse between the soul and the body, the school of Aristotle holding that all objects enter into the soul by influx through the senses; the Cartesians, *per contra*, maintaining that it is the soul that sees and hears, that perception is a primary faculty, not of an organ, but of the soul; while Leibnitz and his followers, denying alike the imagined influx from the body into the soul, and from the soul into the body, maintain the existence of a joint consent and coeval operation of both under the influence of a so-called pre-established harmony.

Passing from the earlier metaphysical speculators to Kant (1724–1804), we find once more in the history of human struggles after truth how much easier it is to destroy than to construct. In the firm analytical grasp of that extraordinary thinker ("the most tremendous disintegrating force of modern times") the past fallacies concerning the nature of the soul had scant chance of mercy—the past short-comings as little of escaping exposure. Ancient philosophic creeds crumbled to dust before him. But did he raise any edifice of practical significance on their ruins? Did he identify the soul? Where are they who can fancy that they are the wiser—that they have made a nearer approach to such identification—by accepting his quasi-mystic reveries on the "ego which exists beneath or rather outside consciousness, . . . a noumenon,* an indescribable something, safely located out of space and time, as such not subject to the mutabilities of these phenomenal spheres, . . . and of whos eontologic existence we are made aware by its phenomenal projections or effects in consciousness."† The first clauses of this definition seem pure assumption, soaring aloft beyond the comprehension of ordinary mortals; the latter (granting the premises of the so-called "noumenon") seems a mystified version of a necessary inference. Even Kant himself admits the total concept to be incapable of scientific proof; and of any other form of alleged proof—the so-called transcendental—what is the practical

* The "noumenon" is an "*intelligible* object—that is, one which, if it is to be cognized at all, must be so in and through the *understanding* without any *sensuous* medium" (Kant's "Prolegomena," translated by Bax, p. lxxxvii). This "Ding an sich," "thing in itself," or "noumenon," is held to be the antithesis of the sensuous phenomenon, but the actual relationship of the two was to Kant himself, has been to his disciples, and will presumably prove to the end of time to his successors, the great stumbling-block in the way of thinking out Kant's whole system.

† Quoted by Graham, "Creed of Science," pp. 153, 154. Kant, again, sometimes uses the phrase "the thinking self," as synonymous with soul; and speaks of the "doctrine of body and the doctrine of soul—the first dealing with *extended*, and the second with *thinking*, Nature."

weight? Such "proof," inasmuch as it transcends experience, can never advance beyond the unreality of subjective formulation, can never attain the reality appertaining to objective demonstration. Nay, Kant admits more than this: he grants nothing can really be proved by metaphysics concerning the attributes, or even the existence, of the soul; while holding that, inasmuch as its reality can not, on the other hand, be disproved, such reality may, for moral purposes, be assumed. So that this sublimest of the world's thinkers is obliged in ultimate analysis to admit that ordinary common-sense may prove as successful in wrestling with the problem as the vastest inborn intellectual potentiality intensified by prolonged culture.

Reaching next the modified or hybrid metaphysical and physiological school of the present day (the former element largely predominant), we find one of its most eminent representatives, Bain, seeming to teach that, whatever it is, the soul has but loose connection with the body. "The body might," he assures us, "have its bodily functions without the soul, and the soul might have its psychical functions in some other connection than our present bodies.* But surely, as indeed this psychologist elsewhere himself admits, mind is a function of the body; therefore it follows implicitly from his propositions that *mind may exist without the soul*, whereas the metaphysical contention denies the possibility of thought without it. Note further that this thinker, with wise discretion, shrinks from any disclosure of his own idea, either by affirmation or negation, of the nature of the soul, and leaves us in total ignorance of what he desires us to understand, when on his own behalf he employs the word.

We may remark in passing, that Plato thought the soul could exist without a habitat in the human body. Kant, on the other hand, held it to be beyond our powers to make any affirmation as to the possibility of its separate existence. Dugald Stewart, somewhat in the same vein, held that we "have no direct evidence of the possibility of the thinking and sentient principle exercising its various powers in a separate state from the body." Here, be it observed, the soul, as with Descartes, is a "principle." Is this anything more than a mere *word?* What is the actual *meaning* of the term in this connection? or has it any meaning? What explanation does it furnish of the facts?

The foregoing brief analysis of metaphysical opinion, though obviously and necessarily imperfect, is not one-sided or dishonest, and seems to render the conclusion inevitable that introspective psychology has failed to supply a definite presentment of the nature of soul. Metaphysicians have, in truth, merely postulated its existence and endowed their creation with a series of attributes, the nexus of no single one of which with its assumed factor has ever been made the subject of serious proof; while, in speaking of mind as one manifestation of its activity, they simply ascribe the performance of a positive act (that of

* "Mind and Body," p. 153.

thinking), the mechanism of which they in no wise understand, to an agent (the soul), the mere existence of which they fail to substantiate.

If it be urged on behalf of any class of metaphysical school-men, who may refuse to accept Kant's modest avowal of failure, that they really have succeeded (because to their own contentment) in fathoming the problems of the genesis of mind and the nature of the soul, and that they are not answerable for the defective intelligence of the outside world, which fails to follow them, the physiologist need not hesitate to concede that they soar in a region of visionary transcendentalism, for which his mental bias and material modes of thought have not fitted him either as a worker or a critic. He is as ill adapted for reveling in trains of speculative abstraction, whereof the issue, purely subjective, can never reach the reality of objective demonstrativeness, as the metaphysician for peering through lenses many a weary day and night to verify a single fact, the present obvious value of which may be *nil*, but of which the future story may be written as the starting link of chains of important truths. Between the metaphysical contemplative mind and the scientific observant mind the antagonism is so profound that the union of the two qualities in the same individual, even in very different degrees of potentiality, is the rarest of intellectual endowments.

The physiologist of the pure observation school may, then, admit his deficiency in critical training for the just estimation of metaphysical methods, and this all the more resignedly in that (as we shall by-and-by fully see) metaphysicians are found occasionally confessing, nay boasting, that they fail to understand each other, while they are likewise accused, apparently on justifiable grounds, of not at all times and seasons thoroughly comprehending each man his own individual work. So the physiologist need not trouble himself about methods but ask for results. And this he has ventured to do, conceiving himself entitled by the worth of the latter to gauge the efficiency of the former. While, then, acknowledging in a spirit of homage savoring of of awe the abstract grandeur of the metaphysical intellect and the aims of its activity, he has earnestly but not irreverently inquired, Do you metaphysicians not deceive yourselves? Are you quite sure you do not take words for ideas? Have you or have you not perpetually confounded figments of the brain with realities? To what increments of true knowledge—the real, substantial knowledge of things—can you lay claim? Have you of late done much more than clothe old thoughts in new phraseology—phraseology of greater precision than that it has supplanted, we may fairly concede? Have you not in sober truth been engaged since the dawn of philosophy—*multum agendi, pauxillum agentes* (doing much, accomplishing little)—in a still beginning, never ending, logomachia? Can you point among your fellows to that emphatic unanimity of creed on fundamental questions which shall demand, as its right, acceptance from the out-

side world, before which you pose as the fountain-heads of all ultimate knowledge? Or, have you not, on the very contrary, disagreed absolutely with each other? And, if you doubt each other, may *we* not in turn doubt you all? Is it not true that Kant never mastered, and loudly proclaimed he never could master, the doctrine of Spinoza?* Did not the philosopher of Königsberg declare the system of Fichte to be utterly untenable? Does not Schopenhauer in turn repudiate Kant? Were not the leading principles of Schopenhauer's own system contained, and in some measure worked out, in Fichte's "Wissenschaftslehre"? And did not the same Schopenhauer, having failed to perceive the similarity (carping critics have been found malicious enough to more than hint that perhaps he herein judged wisely), stigmatize that work, the alleged germ of his own, as a "farrago of absurdities"?† Has not J. S. Mill declared it to be characteristic of Hamilton that he seldom or never adhered to any philosophic statement he had adopted, that "an almost incredible multitude of inconsistencies show themselves on comparing different passages of his works with each other," and that his whole system of "intuitional" philosophy is a profound mistake?‡ And is it not equally true that the adherents of the Scotch philosopher seem to have made it plain that his somewhat ruthless English critic never succeeded in understanding him?* Furthermore, has it not been averred by one of his most earnest panegyrists that Kant failed himself to grasp the full import of his own doctrines, that the "new light that was lighted for men" could not illumine his own ideas sufficiently to grasp their total meaning and anticipate the terms of their ultimate evolution?‖ Finally, has not Berkeley with equal truth and candor pronounced the condemnation alike of his own work and of all his fellow-craftsmen in the fatal admission, "*We metaphysicians have first raised a dust, and then complain we can not see*"?△

To the non-metaphysical mind it would indeed appear that the bootless speculations of the pure transcendentalist were calculated on the one hand to dishearten wayfarers on the road to truth by blocking the route with unintelligible mysticism, and on the other to postpone the discovery of a share of Nature's secrets by diverting any available mental power into a wrong channel.◊ How could aught but

* Kant's "Prolegomena," translated by Bax, p. xxxv.

† E. B. Bax, ibid., p. 101.

‡ J. S. Mill, "Autobiography," pp. 275, 276, third edition, 1874.

* Maudsley, "Journal of Mental Science," vol. xi, p. 551.

‖ E. B. Bax, ibid., preface, p. 3.

△ "Human Knowledge," vol. i, p. 74.

◊ So far from its being desirable that that rare form of gift or "acquired mental dexterity," as the introspective faculty is affirmed to be by Sir William Hamilton, should be vouchsafed to cultured mankind at large, the endowment may, without probable ultimate loss to real knowledge, be left in the grasp of the limited class for which its possession is claimed.

failure in solving the problems of mental philosophy be expected from a system, even though that system were sustained by surpassing intellectual force, that ignored the instrument, brain, by which the result, mind, is evolved? What success could be expected from an inquiry into the mechanism of respiration, from which all consideration of the structure, dynamics, and chemistry of the breathing-organs was purposely excluded? Conceive a man proceeding to investigate the respiratory process who had never seen a lung! Should we consider him perfectly sane? How ineffably curious, then, if not ludicrous, does it seem to find Bain announcing, with in some sort the tone of a man who has stumbled on a happy discovery, that it would be worth the while of metaphysicians to learn something of nerves—we presume, impliedly, something of brain also! Still this niggard dole of acknowledgment places the donor at all events in advance of J. S. Mill, who to the very close of his career contemptuously and obtrusively rejected cerebral physiology as a guide, of even the most subordinate value, in the study of mind. Why, the solitary discovery of the connection of aphasia with a special spot in a special gyrus of a special hemisphere of the brain, taken in conjunction with the corollaries logically deducible from that connection, seems a far weightier offering toward the elucidation of the actual mechanism of mind—of the conditions under which Nature works—than all the transcendental guesswork furnished by the toil of metaphysicians from Plato to Schopenhauer.

Nevertheless, the conspicuous failure of purely introspective philosophy, unaided by objective investigation, to establish its special psychic doctrines, does not, on the other hand, disprove the possible independent existence of soul as one of the factors of mind. Such existence may be, or may not be, a reality, for anything that metaphysics show or do not show. The failure of transcendentalism, admitted even by Kant, simply proves that in wisdom which is not of pure and unaided metaphysics lies such lingering hope, as an enthusiast may cling to, of substantiating the reality and the nature of the soul's existence and practical activity. Nor does the failure signify (whatever may be its import as to the efficiency of transcendentalism) that introspection must not be allowed to play a large though far from the solitary part in the attempt to elucidate the nature of mental operations. To reject the help of introspection in analyzing the phenomena of mind would be as illogical, nay fatuous, on the part of the physiologist as the negation of the utility of all objective aid by the bulk of metaphysicians. But in point of fact such rejection is a sheer impossibility, for we can not cogitate without examining consciousness, and when we do this we introspect. Besides, there are facts of mental operation, and laws regulating these facts, which lie without the pale of physiology as an objective factor, facts and laws which can only be even guessed at by the analysis of self-consciousness. The results of

such analysis plainly can not be claimed by a department of inquiry which deals with phenomena physically demonstrable alone; be those results sound or unsound, conclusive or tentative, final or provisional, such as they are, they are the property of introspective psychology alone. Furthermore, there is a large class of psychological concepts framed on a combination of both kinds of evidence, subjective and objective.

PROFESSOR DVORÁK'S SOUND-MILLS.

PROFESSOR SILVANUS P. THOMPSON has made known, through the columns of "Nature," an interesting series of experiments by Professor V. Dvorák, of the University of Agram, in the production of an apparatus which should rotate under the influence of sound-waves in the same way as the radiometer introduced by Professor Crookes rotates under the influence of rays of light and heat. The same idea was suggested independently to several men, among whom were our countrymen, Professor A. M. Mayer, of Hoboken, and Mr. Edison, all of whom have made in the matter researches of great scientific interest. Professor Dvorák has devised four kinds of "sound-mills," as they may be called, two of which depend on the repulsion of resonant boxes, and two on different principles.

One of the instruments is represented in Fig. 1. It consists of a light wooden cross, balanced on a needle-point, and carrying four light resonators—hollow balls of glass, forty-four millimetres in diameter,

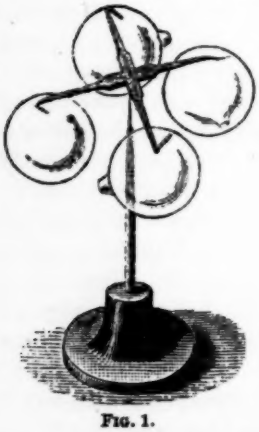

FIG. 1.

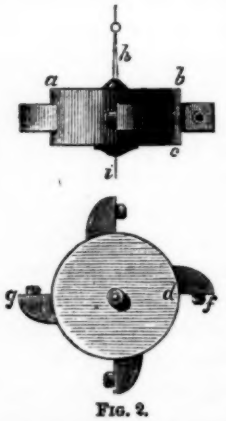

FIG. 2.

with an opening of four millimetres at one side, and responding to the note g', or the middle G, of the piano-forte (= 392 vibrations). When this note is forcibly sounded by the tuning-fork, the air in the reso-

nators vibrates in response, and the apparatus begins to rotate. Rotation will take place even if there is only one resonator, properly balanced; but the phenomenon is more marked and certain if there are four.

A second style of apparatus—the "rotating resonator"—is represented in plan and elevation in Fig. 2. It consists of a short cylindrical box of stiff paper, having four projections, each of which bears at its side a short open tube of paper. It is hung on a silk fiber, and is supplied with a small needle, projecting below to steady the motion during its rotation.

The operation of these instruments depends on the principle which has been pointed out by Lord Rayleigh and Professor Mayer as well as by Professor Dvorák, that "when sounds of great intensity are produced, the calculations, which are usually carried only to the first order of approximation, cease to be adequate, because now the amplitude of motion of the particles in the sound-wave is not infinitely small as compared with the lengths of the sound-waves themselves. Mathematical analysis shows that under these circumstances the wave of the pressures in the condensed part, and in the rarefied part of the sound-wave, is no longer equal to the undisturbed atmospheric pressure, but is always greater. Consequently, at all nodal points in the vibrations of the air in tubes or resonant boxes, the pressure of the air is greater than elsewhere; and therefore any resonator closed at one side and open at the other is urged along bodily by the slight internal excess of pressure on the closed end." The apparatuses therefore rotate by reaction.

To produce vibrations of sufficient intensity, Professor Dvorák uses heavy tuning-forks mounted on resonant cases, and excited electrically. For this purpose he places between the prongs of the fork an electro-magnet, in which the core is composed of two plates of iron, separated by a sheet of paper, and cut of such a breadth as to lie between the prongs without touching them. The core is overwound with insulated copper wire, as shown at E, Fig. 3, and the electro-magnet is mounted by a bent piece of wood, *a b c*, upon the sounding-box, K, of the fork. The wires are connected in a circuit with the battery, and with the electro-magnet of a self-exciting tuning-fork of the same note. The sounding-boxes of the forks must not touch the table, but the arm *a b c* is clipped at about the point *b* in a firm support; and particular care must be taken to have the wood of the resonant boxes tuned into exact accord with the tone of the fork and of the air within the cavity of the box.

The third apparatus is the "sound-radiometer," and was described by Professor Dvorák before the Imperial Viennese Academy in 1881. It is more simple than the two instruments previously described, but its cause of action is less easily explained. It is shown in Fig. 4. It consists of a light cross of wood pivoted by a glass cap upon a vertical

needle, and having attached to its four arms four pieces of white card, perforated with holes which are depressed conically on one side and raised at the other, so as to present a surface something like that of a nutmeg-grater. Each card has twenty-five holes thus pierced, and the

Fig 3.

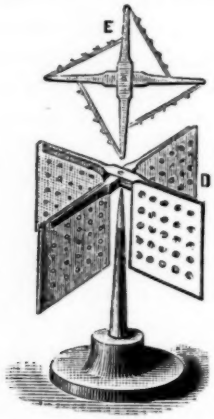

Fig. 4.

whole apparatus a hundred holes. The rotations are more rapid if the cards are set on obliquely in the fashion shown at E in the figures, with the burred sides outward. The rotations are produced when the "mill" is set in front of the resonant box.

Dvorák's fourth apparatus is called by him an "acoustic anemometer," and is represented in Fig. 5. It consists of a little "mill" of simple construction, *h i k*, the vanes of which are made of small pieces of paper or card slightly curved, and a sounding-box, *c d f g*, placed a little way from it, while between them is held an ordinary Helmholtz's

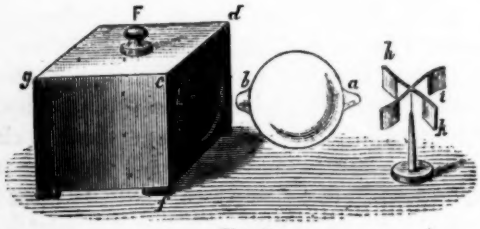

Fig. 5.

resonator having its wide opening, *b*, turned toward the box, and its narrow opening, *a*, toward the mill. The stem of the tuning-fork is inserted in the socket F of the sounding-box. The internal increase of pressure induced by the vibrations of the tuning-fork through the sounding-box in the resonator at *a* has the effect of driving a jet of air gently against the sails of the mill, which consequently rotates. The two-aperture resonator of this apparatus may be replaced by a

resonator having but one aperture, which may be formed of a glass ball cut away at one side and cemented to a glass plate having a small hole in the center. When the air ejected from the mouth of the resonator is examined by the method of mixing smoke with it, and then viewing it through slits cut in an open disk, the currents are seen to consist of a series of vortex rings. A variation of this anemometer may be made by taking a card pierced with a hundred holes and placing it between the resonant box and the "mill," when the latter will rotate in the wind which passes through the conical holes.

The machines of Mayer, Mach, and others, are closely akin to those of Professor Dvorák in design and action. Mr. Edison also has contrived a phonometer, or instrument for measuring the mechanical force of sound-waves produced by the human voice, in which the vibrations produced in the phonograph-diaphragm by a sound made in the mouth-piece propels a finely-cut ratchet-wheel with considerable velocity. With this device Mr. Edison has "literally accomplished the feat of talking a hole through a deal board."

ARNOLD HENRY GUYOT.

By Professor W. B. SCOTT.

THE political disturbances of 1848, injurious as they were to Switzerland, were directly a great gain to America, for they gave to this country both Agassiz and Guyot, for a long time co-laborers for the advancement of American science and the diffusion of sound learning among the people. "We are led to wonder how much scientific progress would have been delayed in this country if it had not been for the inspiring and co-operating influence of these noble immigrants."*

Arnold Henry Guyot was born near Neufchâtel, Switzerland, September 8, 1807. His early education was obtained at his native town, and it is interesting to note that during his school-life there he was president of the gymnastic club, and one of the best of the school athletes. His slight, wiry frame thus received a training in strength and endurance which afterward stood him in good stead when he undertook the immense labors of glacier-study in Switzerland and of mountain-surveying in America. On leaving Neufchâtel he went to complete his studies in Germany, attending successively the gymnasia of Stuttgart and Carlsruhe. At Carlsruhe he was an inmate of the family of the Brauns, and there met his countryman Agassiz, who, with Imhoff and Carl Schimper, was making a vacation visit to his friend Alexan-

* "Science," No. 55, p. 220.

der Braun. This period was one of the critical points in Guyot's career. There was formed that close and tender friendship with Agassiz which lasted until the latter's death, and found its final expression in the beautiful memoir of Agassiz which Guyot prepared for the National Academy of Sciences in 1877. But of still greater importance was the impulse toward the study of science which he received from the enthusiastic group of young naturalists with whom he was thus brought into daily and hourly contact. He says of this period: "My remembrances of these few months of alternate work and play, attended by so much real progress, are among the most delightful of my early days. . . . It would be idle to attempt to determine the measure of mutual benefit derived by these young students of Nature from their meeting under such favorable circumstances. It certainly was very great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued and subsequently performed his life-work."

In 1829 young Guyot went to Berlin in order to complete the theological studies which he had begun at Neufchâtel; but the love of science was strong within him, and the new field which the lectures of Steffens, Hegel, and Ritter opened up to his view decided him to enter upon the study of Nature as his life-work. Having thus decided, he determined to lay his foundations broad and deep, and with this end in view he attended lectures on nearly all departments of natural science: chemistry, physics, meteorology, zoölogy, geology, and physical geography, alike received attention, and his subsequent career showed the great wisdom of this thorough preparation. In 1835 he received the degree of Doctor of Philosophy, and at once proceeded to Paris. Here he resided more than four years, quietly pursuing his preparatory studies and extending them in vacation by tours of observation through various European countries. He also took up the subject of history under Michelet, and, like everything else which he touched, made it valuable in the great pursuit of his life, the study of earth and man.

In the spring of 1838 Agassiz came to Paris, enthusiastic upon the subject of glaciers, and this induced Guyot to turn his attention in the same direction. In the summer of the same year he went to Switzerland and began his work on the glaciers of that country. The results of the summer's work were presented in a paper before the Geological Society of France during the session of 1838, at Porrentuy. This paper is mentioned in the "Proceedings" of the society ("Bulletin," vol. ix, p. 407), but, owing to a long illness of the author during the following winter, it could not be printed. The great laws of glacial phenomena first enunciated by Guyot in this paper were afterward announced as new discoveries by other observers, and were the occasion of bitter quarrels. Afterward, when a discussion arose between Forbes and Agassiz, the manuscript was, on motion of Agassiz, and by

a formal vote, deposited as a voucher with the Society of Natural Sciences at Neufchâtel, and was printed by that society in 1883. This paper contained the following contributions to the subject: 1. The sloping of the terminal beds of glaciers toward their interior, and their origin as closed-up crevasses. 2. The laminated structure or blue bands of glacier-ice. 3. The cause of the fan-shaped disposition of crevasses. 4. The more rapid motion of the glacier's center than of the sides. 5. The more rapid motion of the top than the bottom of the glacier. 6. The movement of glaciers which takes place by means of a molecular displacement, whence results the plasticity of the glacier. Later, he added the law of the formation of transverse crevasses in a plane perpendicular to the steepest slope of the glacier. With rare modesty Guyot never took part in the fierce discussions caused by the claim laid by others to his own discoveries, contenting himself with a simple statement of the facts published long afterward in his memoir on Agassiz.

In 1839 Guyot accepted a call to the Academy of Neufchâtel, where his friend Agassiz was then settled, and there he remained till his removal to America in 1848. His chair was that of History and Physical Geography, and he regarded the years of his work there as the period of his greatest intellectual activity. During this time he gave much attention to his glacial work, taking up the geological side of the question, the erratic blocks and ancient extension of the glaciers, and devoting to this work "absolutely single-handed, seven laborious summers, from 1840 to 1847." This gigantic undertaking was brought to a successful conclusion, though the results were but partially published, inasmuch as the "Système Glaciaire," by Agassiz, Guyot, and Desor, never went further than the first volume (Paris, 1847). Guyot's collection of five thousand erratic rocks, illustrating eleven erratic basins, now fills a room in the Princeton Museum, a monument of incredibly pains-taking labor.

The political disturbances of 1848 induced Guyot to follow his friend Agassiz to America, and he lived for some time at Cambridge, Massachusetts. He first attracted public attention by the remarkable series of lectures afterward published in the well-known book "Earth and Man." These lectures were the starting-point of a great reform in the historical and geographical teaching of this country. For six years he was engaged by the Board of Education of Massachusetts as a lecturer to the normal schools on geography and the methods of teaching it, and after he came to Princeton he followed up the work there commenced by preparing a series of geographical text-books and large maps. To use the words of a recent writer in "Science" with regard to these books: "It is not too much to say that they revolutionized the methods of teaching geography. Every series of geographies which has since appeared shows the influence of Guyot." He threw aside the old routine methods, and brought the pupil face to face with Na-

ture, showing the bearing of the earth's physical features upon every department of human interest.

Another pre-eminent service which Guyot rendered to America was the work he did in meteorology, a science which had received very little attention when he arrived in this country. From 1851 to 1859 he worked at the preparation of the "Meteorological and Physical Tables," published by the Smithsonian Institution, and also superintended the construction of accurate meteorological instruments. In connection with Professor Henry he must be regarded as the founder of the system of weather observations and reports which has resulted in the Government Signal Service.

In 1854 Guyot was elected to the chair of Geology and Physical Geography at Princeton, a post which he filled for the thirty remaining years of his life. Until compelled to cease by the increasing infirmities of age, he devoted all his vacations and spare time to his favorite investigations, making elaborate and careful examinations of the mountains from New England to South Carolina. This work involved an immense amount of hardship and fatigue, and he was fond of describing with quaint picturesqueness and humor his experiences in roughing it in the mountains of Pennsylvania and the Carolinas. In 1861 he published in the "American Journal of Science and Arts" the results of his work up to that time, "a memoir which remains to this day the best existing description." Again, in 1880, he brought out another memoir on the same subject, devoted chiefly to the Catskills, some of the rough work for which was done after he was seventy years old. Many shorter papers on meteorological, physical, and geographical subjects were written at intervals, but no complete list of them has ever been prepared. His work during this period is a noble example of what may be done without appropriations or endowments, for in those days Princeton was very poor, and he had to do as best he could without assistance.

As a friend and teacher Guyot will ever be held in loving remembrance till the last of his hundreds of students shall have followed him to the grave. His lectures were wonderfully fascinating, leading his hearers step by step to heights whence they could survey the whole field. His broad culture, gained by the combination of the humanitarian and scientific studies, had given him an extraordinary power of generalization, stimulating his students by showing them the relations of any subject which he handled to the whole realm of knowledge. He was able to depict these sciences in their true perspective without distortion or exaggeration, a power which is unhappily very uncommon. Those who had the rare privilege of pursuing advanced courses of study under his supervision will long remember the great stimulus to earnest work which they received from him, and the clear, philosophical views of Nature which he expounded.

For many years Guyot labored under great disadvantages from the

lack of proper appliances, but he never allowed these drawbacks to lower the character of his work. When Princeton's day of prosperity came, he showed that he knew how to apply money wisely, as before he had been able to do grand work without it. The system of scientific expeditions to the West, which has so greatly stimulated the study of natural science at Princeton, and added so greatly to the treasures of her museums, was organized under his direction; and the wonderful growth of all the departments of natural science in the college must be in very large measure attributed to the wisdom and foresight of Guyot.

The visible monument of Guyot's work in Princeton will always be the Museum of Geology and Archæology. He expended with consummate skill the sums placed at his disposal by generous friends, and organized an enthusiastic corps of workers, so that a superb series of collections has been gathered. Thus in every department of activity his influence has been of the utmost service to Princeton in particular, and to American science in general.

But even this brief and imperfect sketch can not close without some testimony to his noble and exalted character, modest, unselfish, and devoted. "He never seemed to be thinking of himself, but always of his subject and his hearers. He cared very little for fame, very much for the study of Nature and the education of man." * An earnest and consistent Christian throughout his life, he was ever charitable and tender, never indulging in acrimonious criticism or denunciation of those who differed even most widely from him. Always liberal, he sympathized with and appreciated honest opinion on whatever side it was uttered. He was remarkable for "the beauty in his daily life as well as for his nobly finished work." There is little cause for grief in the quiet close of such a splendid, useful, and complete career as this; nevertheless, we must mourn our irreparable loss, sorrowing most of all that we shall see his face no more.

* "Science," *loc. cit.*

EDITOR'S TABLE.

THE PROGRESS OF MENTAL SCIENCE.

IT is gratifying to remark the steady and assured advance of psychological research on the objective or corporeal side, or what is now better known as mental physiology. Without denying the validity of the old method of studying the mind by introspective observation, or that there are regularities and uniformities in the changes of consciousness thus revealed which are the proper subject-matter of science, it is still true that this method does not reach down to the conditions which give law to mental operations, and can not deal with the most fundamental questions of psychical science. It is the organic side of mind which determines mental phenomena, and the science of mind is, therefore, radically incomplete until the nervous system is made the basis of exploration in its manifestation of psychical effects. It can hardly be said that there was anything entitled to recognition, as a proper science of mind, until the bodily conditions and concomitants of feeling and thought became an essential part of the study, and, when that was done, the progress of knowledge upon the subject was clear, decisive, and in the highest degree important. To appreciate the latest phase of this interesting research, it will be desirable to recall some of the signal steps of advancement which have been made in recent years in this line of investigation.

Throughout past ages, from the ancient classical period onward, although philosophy was ever busy with questions concerning the nature and powers of the soul, nobody dreamed that it had a fixed and definite working relation to the universe through the living mechanism with which it was associated. The anatomy and physiology of the last century, however, prepared the way for the successful elucidation of the subject, and the first great step forward was made by Sir Charles Bell about the year 1825, in establishing the double action of the nervous system, or that impressions from the external world pour in upon the brain through one set of nerve-lines, while all the mandates of volition controlling human activity are transmitted outward along another system of nerve-lines. This was a triumph of anatomy and experimental physiology, and a very striking fact, yet the profound significance of the discovery could not be at all appreciated at the time, as it derived its chief importance from the train of disclosures that grew out of it.

It was at first supposed that all peripheral impressions are sent directly to the brain or sensorium, and that all commands of the will are also transmitted uninterruptedly from the brain to the muscles. But about 1840 Dr. Marshall Hall made another capital step of progress by establishing the reflex function of the spinal cord, or by showing that the spinal centers have a control of muscular movements and organic processes independent of the brain. The element of automatism in the working of the living machinery was here brought out, and it was discovered that there are self-working systems in the living economy, by which important gradations of effect are secured. The lower and simpler centers of the spinal system control the fundamental processes of organic life, involving the action of the heart, and the respiratory and digestive apparatus. It is as if these could not be intrusted to the higher organ of volition, which, becoming exhausted, sinks daily into inaction and unconsciousness, but

must be committed to specific centers which act with automatic certainty and never sleep.

Pursuing this line of inquiry, a third important step was taken by establishing the separate and automatic functions of the sensory ganglia at the base of the brain and the summit of the spinal column. Impressions from the surface reaching the spinal centers are passed upward to the sensory ganglia, and there give rise to sensations and emerge into consciousness, reflex action being here extended to conscious movements. Dr. Carpenter did much to unravel this branch of the subject about 1850, and his work on "Mental Physiology," published within a few years, will be found full of interesting and important information in relation to it. The problems entered upon were, of course, of great complexity, obscurity, and difficulty. Dr. Laycock had carried the doctrine of reflex action into the cerebral hemispheres, and shown its importance in the higher operations of the mind; and it yet remains a sharply debated question among nervous physiologists how far the principle of automatism extends in the higher realm of our psychical life.

It was thus gradually established that all mental operations, all thought, feeling, instinct, and volition, are the results, first, of the activity of the primary nervous elements, cells, and fibers, by which nervous influence is accumulated and discharged; and, second, of the interaction of numerous automatic centers variously endowed, but communicating with each other solely by the transmission of nervous force. The gain thus secured to mental science on its practical and progressive side was very great. The subject took its place among the definite and experimental science of the natural world. Nothing is so vague as the conception of mind from the metaphysical point of view. Quantitative results are unattainable by that method, and all limitations are scorned by it as degrading to the dignity of spiritual being. But in inquiring into the functions of the nervous system we are at once deeply involved in the physiology of limitations. Mind-force can not come from nothing, any more than other forms of force, and here as elsewhere one effect is at the expense of another. Thinking and feeling exhaust the mechanism, and we are involved with practical questions of waste and repair, exercise and rest, food, blood, nutrition, and the hereditary qualities of the nerve-centers.

Here also the study of mind widens out into the comprehensiveness of a true science by including all the grades of animal life as objects of psychological study. For here as well as everywhere else the higher is to be interpreted by the lower, the complex by the simple, and no animate creature is so far down in the scale that it does not illustrate some phase of mind which has a bearing upon the mental problems of higher beings. The introspective method of course breaks down here. Confined to the adult mind, it excludes the minds of children, and therefore the study of the laws of mental growth; confined to the human mind, it excludes those of all inferior beings. Yet when it becomes a question of determining the properties of nerve-centers, the nature of reflex action, of instinctive movements, and all forms of the laws of intelligence, then comparative psychology makes invaluable contributions to mental science.

And there is still another division of the study of mind of supreme importance, to which very little was or could be contributed by the old method, but which is making marked progress by the more recent methods of investigation: we refer to the subject of insanity. When we come to mental derangements, introversive study is obviously fruitless, and so long as that was pursued nothing was known of the nature of insanity. Mental disease in

its basis and causation is bodily disease, and the multitudinous forms of mental weakness, degeneracy, and aberration are to be studied as effects of corporeal infirmity or disease of the nerve-structure. The light thrown upon the science of mind through the manifestations of mental failure has been of great importance, and physiological investigation has now brought us to another and very significant aspect of the subject.

For all scientific men the doctrine of evolution is established, and its highest interest to them is that it is constantly giving new clews to the interpretation of nature and opening new avenues to productive research. This doctrine teaches that the grades of life have arisen in past ages through the operation of laws by which the higher have been derived from the lower. But if this be true, then the nervous systems of animated beings are to be regarded as products of evolution, so that the hierarchy of nervous centers of which we have spoken has been built up by the successive attainment of higher and higher levels of organization. Man, as the latest product and highest term of evolution, combines in his organism the various automatic systems successively reached in the long course of organic development. Biology works out the great laws of upward and divergent unfolding, but there is another side to the phenomena which it is the business of pathology to investigate. Corresponding to the progressive and upward changes of evolution, there are the downward and retrogressive changes of dissolution, by which the constructive work is reversed and undone. But, if we have a true theory of the way the nervous system of man has been evolved, will not that theory afford guidance concerning the order of dissolution, and throw light upon the nature of nervous maladies and mental derangement? This question has been answered affirmatively. We print a lecture by Dr. J. Hughlings Jackson, the first of a course before the Royal College of Physicians in London, on the "Evolution and Dissolution of the Nervous System," in which the subject is treated from the point of view here indicated. Dr. Hughlings Jackson is not only an eminent practitioner in the department of nervous diseases, but he is an able philosophical student of medical subjects, and, although the Croonian lectures are addressed to medical men, the one we print will be found of general interest as opening a new chapter of original investigation in this important field of research.

A MODEL BENEFACTION.

It is announced in the papers that Mr. Andrew Carnegie has given the sum of fifty thousand dollars to the Bellevue Hospital Medical College of this city, for the erection and equipment of a building to be devoted to original investigations on subjects connected with the progress of medicine and the prevention of disease. Mr. Carnegie is well known as a man of large liberality who has accumualted a fortune by his own enterprise, and uses it generously in the promotion of projects of public and private beneficence. We have before had occasion to observe the wise discrimination of his contributions, but in this case he has undoubtedly devoted his money to the noblest use for which money can ever be expended. The endowment of hospitals and dispensaries for the immediate relief of suffering is, of course, highly commendable, and they are so obviously necessary, and their benign results are so direct and palpable, that sympathetic charity is ever ready to lend them support. But that is a more far-sighted and efficient benevolence which provides for the extension of medical knowledge, the research into the causes and conditions of disease, and the increase in the resources of medical art, by the systematic scien-

tific investigation to which we owe all the progress that has yet been achieved in this important field. There has never been a time in the history of medicine when the need of independent original research was so great as now, when the questions demanding elucidation were so numerous and so grave, and the encouragements to their pursuit so promising. The sciences of observation and experiment have done much for the world in many ways, and the medical art has fully shared in the advantages they have conferred; but work in this direction is modern, and that which has been accomplished is as nothing to what yet remains to be done. It is well for the medical colleges to teach what is known, but they need to know a great deal more, and it is certainly high time that we should have a class of professional investigators in this country so thoroughly qualified and prepared for their work that our students will not have to go to Europe after the facilities for profound and exhaustive research. Mr. Carnegie's gift, by establishing an ample and well-appointed laboratory for the experimental study of important medical subjects, will favor the progress of American science, at the same time that it promotes those interests of humanity that are wider than nationalities. The questions to be taken up in such an institution and that are now in most urgent need of solution are many, and one of them was so well stated by a writer in a morning paper that we quote it:

Histological investigations — that is, by means of the microscope—have within late years shed much light on the heretofore occult processes taking place in the different parts of the body in health and disease, and, quite recently, scientific developments in this field of study have shown the vast importance of these investigations, together with experimental researches, as regards our knowledge of micro-organisms. Already it has been demonstrated that several of the infectious diseases are caused by specific parasitic bacteria, and it is more than probable that investigations now in progress will lead to further discoveries rendering preventable and controllable many diseases which occasion much human suffering and contribute largely to mortality. It is, perhaps, not extravagant to say that the discoveries already made, conjoined with those which are foreshadowed, will prove of greater importance in their influence on the science and practice of medicine than any since the great discovery of the circulation of the blood by Harvey.

LITERARY NOTICES.

A Treatise on Insanity in its Medical Relations. By William A. Hammond, M. D. New York: D. Appleton & Co. Pp. 767. Price, $5.

Whether insanity is on the increase throughout the civilized world, as is claimed by many and is certainly not improbable, or whether the apparent increase is due to increasing knowledge in regard to its real extent, the growing interest and importance of the subject are not to be questioned. It is impossible that science should not have made great advances in the elucidation of this most complex subject, depending as it does upon the progress of physiology, psychology, pathology, and therapeutics, and cultivated by specialists as an independent branch of practical medicine; while through the whole historic period down to quite recent times the ignorance, prejudice, and barbarism that have been displayed by society toward the most unfortunate of our fellow-creatures have been one of the darkest chapters of human experience; on the other hand, the spirit of investigation can offer no triumph so great as that which has been achieved by the medical profession in dispelling old prejudices and illusions, and giving a rational account of the conditions, causes, and diversities of mental alienation. The subject is, indeed, yet full of obscurity, and far enough from having been cleared up, but great steps forward have been taken, and in no field is there more continued activity of research. Dr. Hammond's comprehensive and able work is a contribution to the subject made in the light of the latest achievements in all its dependent branches of inquiry. We have looked through his treatise with much interest and constant instruction, and have already given in the "Monthly" some important passages from

it as it was going through the press. We have been struck by one feature of the treatise, which indicates an important advance, and which involves the author's fundamental view of the subject. He draws a line between legal and medical insanity, and shows that the latter conception is far wider, taking into account slight mental failures which legislation can not recognize. His work is not on the medical jurisprudence of insanity, which deals with the subject entirely on the legal side, but it is a scientific inquiry into all grades and forms of mental aberration, and deals with the subject with reference to the treatment of mental disease rather than the responsibilities of the alienist class. We quote the author's statement in his preface of these views by which he has been guided in the preparation of the work:

I have long been convinced that the term "insanity" has hitherto been applied in altogether too limited and illogical a manner. It has been understood, both in and out of the profession, that a person, in order to be considered the subject of mental aberration, must, at some time or other, present certain marked symptoms, which he can not avoid exhibiting, and which are sufficient to indicate to the world that he is not in his right mind.

Starting from the points that all normal mental phenomena are the result of the action of a healthy brain, and that all abnormal manifestations of mind are the result of the functionation of a diseased or deranged brain, I do not see why these latter should not be included under the designation of "insanity," as much as the former are embraced under the term "sanity." There can be no middle ground, for the brain is either in a healthy or an unhealthy condition. If healthy, the product of its action is "sanity"; if unhealthy, "insanity."

Of course very little of such insanity comes under the signification given to the word by lawyers and the public generally. But legal insanity and medical insanity are very different things, and the two standards can never and ought never to be the same. The law establishes an arbitrary and unscientific line, and declares that every act performed on one side of this line is the act of a sane mind, while all acts done on the other side result from insane minds. This line may be in one place to-day, and in an entirely different place to-morrow, at the whim or caprice of a Legislature; it may be established on a certain parallel in one country, and on an entirely different parallel in another country. In the State of New York, for instance, it is drawn at the knowledge of right and wrong; and perhaps, all things considered, this is about as correct a legal line as a due regard for the safety of society will permit to be made. But every physician knows that it is absolutely untenable from his point of view; that it is not a medical line, and that there are thousands of lunatics insane enough to believe themselves to be veritable Julius Cæsars, and yet sufficiently sane to know that a particular act is contrary to law, and to be fully aware of the nature and consequences of such act. Hence it follows that, from a medical stand-point, there is no middle ground between sanity and insanity. The line of demarkation is sharply drawn, and it is but a step from one territory to the other. There is a large proportion of the population of every civilized community composed of individuals whose insanity is known only to themselves, and perhaps to some of those who are in intimate social relations with them, who have lost none of their rights, privileges, or responsibilities as citizens, who transact their business with fidelity and accuracy, and yet who are as truly insane, though in a less degree, as the most furious maniac who dashes his head against the stone-walls of his cell. To many of these persons life is a burden they would willingly throw off, death concerned them alone, for they are painfully conscious of their actual suffering, and morbidly apprehensive in regard to the future. There are very few people who have not, at some time or other, perhaps for a moment only, been medically insane. It is time, therefore, that the horror of the word should be dissipated, and that the fact should be recognized and acted upon, that a disordered mind is just as surely the result of a disordered brain as dyspepsia is of a deranged stomach; that a scarcely appreciable increase or diminution of the blood-supply to the brain will lead as surely to mental derangement of some kind as an apparently insignificant change of the muscular tissue of the heart to fat will lead to a derangement of the circulation, and that in the one case there may be a hallucination, a delusion, a morbid impulse, or a paralysis of the will, just as in the other there may be an intermittent pulse, a vertigo, or a fainting-fit. There is no more disgrace to be attached to the one condition than to the other.

AN EXAMINATION OF THE PHILOSOPHY OF THE UNKNOWABLE AS EXPOUNDED BY HERBERT SPENCER. By WILLIAM M. LACY. Philadelphia: Benjamin F. Lacy. Pp. 235.

THIS volume is a metaphysical onslaught on Herbert Spencer's metaphysics, and may be recommended to all interested in the subject as acute, subtile, ingenious, and very well stated. A writer in "Science," reviewing the book, declares that the task of refuting Spencer's doctrine of the unknowable is merely flogging a dead horse, and he expresses surprise that "a man of extraordinary keenness and vigor of thought should waste so much speculation upon the subject." The aforesaid writer in "Science" is also greatly scandalized that the metaphysician Lacy is so grossly ignorant of the rudiments of physical science, and he takes some pains to expose the au-

thor's blundering stupidity in regard to the first law of motion. But the curious thing about it is that the writer in "Science" is inclined to attribute the scientific incapacity of this metaphysical author to Spencer himself, or, rather, to make it a result of familiarity with Spencer's works. He says: "Meanwhile, let the case serve as a warning to those who imagine that our American public is to receive useful instruction in elementary physical science from the now popular works of the great teacher of the evolution philosophy. Here is a very good student, indeed — diligent, logical, and ingenious. What philosopher could hope for a better? He has carefully studied Mr. Spencer's works, and this is what he has got out of them." A gem of judicial criticism, truly, of which "Science" may well be proud!

INDIANA: DEPARTMENT OF GEOLOGY AND NATURAL HISTORY. Eleventh Annual Report, 1881. Pp. 414, with 55 Plates. Twelfth Annual Report, 1882. Pp. 400, with 38 Plates. By JOHN COLLETT, State Geologist. Indianapolis, Ind.

INDIANA possesses much geological interest. The formations, from the Lower Silurian to the Carboniferous, are well exposed in their order from east to west, and abound in limestones and sandstones suitable for varied economical purposes, lime, cement, and coal, while the northern part of the State is deeply covered with glacial drift. Springs and streams abound. The soil in the central and northern parts is deep, and contains the elements of a prolonged fertility. As late as 1880 timber was spoken of in Professor Collett's report as still in excess. It is of hard wood, and suitable for fine work. Coal is found in fields covering an area of 7,000 square miles, which are entered in all directions by railroads. The non-caking "block-coal" is found within an area of 600 square miles, and is a valuable metallurgical agent. The coal-mines employ a capital of $2,500,000, and the same sum represents the value of the product of 1882. The building-stones are of various and excellent qualities. The oölitic limestone of Lawrence, Monroe, Owen, Crawford, Harrison, and Washington Counties is easily worked, develops in hardening a strength of from 10,000 to 12,000 pounds to the square inch, takes on an agreeable color, is of unprecedented purity, and gives a promise of durability. Pure glass sand is found in four counties, gravel is "common as air," lime and cement are "so abundant as to escape attention"; brick-clay is "as common as water"; kaolin and fire-clay occur in workable beds, natural gas is mentioned, and some salt is produced. Fine fossils abound in all the formations. Professor Collett has added much to the value of his reports by calling in the aid of persons already familiar with the geology of the State and their own counties, and of scientific experts. In these volumes and the preceding report for 1880 we have, besides the special surveys of ten counties, descriptions of fossils by Dr. J. C. McConnell, of Washington, D. C., Professor James Hall, and Dr. C. A. White; a paper on palæozoic botany, by Professor Lesquereux; a flora of the elevated region of the State; and a microscopic study of potable waters, by the Rev. Dr. Curtis. Special attention is given to archæological features.

A TEXT-BOOK OF THE PRINCIPLES OF PHYSICS. By ALFRED DANIEL, M. A., Lecturer on Physics in the School of Medicine, Edinburgh. London: Macmillan & Co. Pp. 653. Price, $5.

IN its general method this book follows the "mode of teaching under which the whole of natural philosophy is regarded as substantially a single science, in which scattered facts are collected and co-ordinated by reference to the principles of dynamics and the great experimental law of the conservation of energy." The treatise confines itself strictly to the field denoted by its title, applications of principles and matters of solely historic interest being rigidly excluded. After some preliminary considerations of measurements, including the measurement of force and of energy, there is a chapter devoted to kinematics, in which waves and simple harmonic motions are treated at considerable length. The essential or general properties of matter are next stated, and then the characteristics of each of the three states of matter. The opening of the chapter on heat well illustrates the character of the book, and is as follows:

Heat is a form of energy. It would, perhaps, indeed be more correct to say that we designate under the one name heat two totally distinct forms of

energy. The one of these is the energy of a wave motion in the ether, passing from a hot body to surrounding objects across the intervening space, as from the sun to our earth, or from a hot fire to the colder objects upon which it shines: this we call radiant heat. The other form is a confused oscillatory disturbance of the particles of a body: in virtue of this molecular movement a body may appear to our cutaneous sense of heat (a sense quite distinct from that of touch) to be more or less hot or warm; or, in the converse case it may, on account of the small amount of this movement, appear to be relatively cool or cold. The latter form of heat may be called sensible heat, or heat simply, and of it we shall proceed to treat in this chapter.

"Of Ether-Waves" is the heading under which the phenomena of radiation, including reflection, refraction, and interference, are treated. In defining electricity and magnetism, the author states that they "are not forms of energy; neither are they forms of matter. They may, perhaps, be provisionally defined as properties or *conditions of matter;* but whether this matter be the ordinary matter, or whether it be, on the other hand, that all-pervading ether by which ordinary matter is everywhere surrounded, is a question which has been under discussion, and which may now be fairly held to be settled in favor of the latter view." Although the author, in his preface to this solid volume, expresses the modest hope that it may "be found fitted to serve as an elementary introduction" to a course of wider reading and practical study, it is by no means a book for immature students. It is illustrated with about two hundred and fifty diagrams.

THE RELATION OF ANIMAL DISEASES TO THE PUBLIC HEALTH. By FRANK S. BILLINGS, D. V. S., etc. New York: D. Appleton & Co. Pp. 446. Price, $4.

THE subject considered in this volume is one of great practical importance both to individuals and to the community at large. The author is a veterinary surgeon of eminent standing, a graduate of the Royal Veterinary Institute of Berlin, and honored by various kindred institutions and societies. In addition to the qualifications thus attested, Dr. Billings has another excellent requisite for the task he has undertaken, which is deep feeling upon the subject—an interest inspired of large knowledge—in fact, an intense enthusiasm well suited to the kind of work he has in hand. He writes with vigor, and often with a vehemence that might involve exaggerated statement; but we must remember that his work is not a treatise on veterinary practice, or a manual of medical and surgical treatment of diseased animals, addressed to the profession. It is a work on the *prevention* of disease, addressed to the general intelligence of the community, and designed to draw attention to questions and to stir up a popular interest in them that shall lead to private and public action, and for this purpose strong language is entirely justifiable. His subject, moreover, is one upon which there is not only much ignorance among otherwise well-informed people, but upon which there is also a great deal of narrow and unworthy prejudice, deserving of unsparing exposure and severe denunciation.

The work is divided into three parts. The first, of 208 pages, is devoted to "The Diseases of Domestic Animals"; Part II, of 155 pages, describes the "History of Veterinary Medicine" and the establishment of veterinary schools; Part III, of 51 pages, treats of "The Means of Prevention" by veterinary schools and institutes and a veterinary police system in the United States. The first part is taken up with a consideration of some of the most important infectious and contagious diseases of animals—those which require both scientific knowledge and official authority for examination and repression. An intelligent writer in "The Journal of Comparative Medicine and Surgery" thus refers to the subjects here discussed:

"Trichiniasis" in men and animals is dealt with in pages 1 to 40, and is a capital study indeed. The ready detection of the disease in slaughtered hogs, about the pillars of the diaphragm, is especially important. But the author has Bismarckian views about the "great American hog," which may raise an unjust howl from those whose pockets will be touched. We hope they will, for the intrepid doctor is fully capable of dealing with them, and he should have his chance. It will be a hard fight and a good one. Before Government acts in the matter, all large pork-packers should have skilled examiners, licensed from some good veterinary college, to inspect and mark their products. These will find a more ready sale, at higher prices, than less well-attested articles. These certificates will doubtless have a higher standing than those of some Government officials, appointed for some political reasons only or mainly.

Next to hogs, *trichinæ* are apt to infest rats, and the doctor says: "Continued examinations of rats should be made in all parts of the country, and

their slaughter encouraged in all legal ways. In this regard we can even look upon the rat-pit as serving a useful public purpose, and the rat-invasion theory, with reference to hogs, will receive a sooner final settlement." But Mr. Bergh will surely interfere here, and, when Greek meets Greek, will come the tug of war. The directions for the prevention of trichinæ in swine, p. 31, are excellent, although little is said about disinfection, above which cleanliness, inspection, branding diseased hogs, etc., are preferred.

"Hog-cholera" occupies pages 41 to 50. This chapter is short, but excellent. The cause of the disease, *Bacillus suis*, is well tracked down, the microscopical examinations well given, and the preventive measures thorough — down, in extreme cases, to slaughtering the infected animals in their own pens, and burning the latter, with all contaminated wooden utensils. Sheep and rabbits are subject to what is called "hog-cholera," and require attention in places where the disease prevails.

"Tape-worm" in hogs and cattle is treated of in a short but masterly way. The *Tænia medio-canellata* comes from beef, which is especially dangerous when eaten raw or very rare. *Tænia solium* comes from pork, and affects those who eat raw ham and underdone pork, and slightly smoked and cooked sausages. This chapter should have had a distinct heading, which is lacking, and may be overlooked by all who do not read the book regularly and carefully through. The same suggestion applies to the chapter on "Foot-and-Mouth Disease," or *contagious eczema* of cattle. This infection is also apt to implicate sheep, swine, goats, deer, occasionally horses, and sometimes dogs and turkeys. Cases in children in New York have occurred, apparently from the use of contaminated milk; and the disease is cropping up in various parts of the country, both far North and far West. It has possibly been imported by English cattle which have escaped quarantine inspection, although the spontaneous generation of a similar disease, where cattle live in marshes and filth, can not well be denied. Eczema, or salt-rheum, is the most common skin affection in human beings, and how much of it comes from cattle is not yet determined. Bollinger says: "Notwithstanding the ruling opinion to the contrary, the disease is much more common among human beings than is suspected." The suggestion of Dr. Billings, that milk should be examined for much more than mere dilution with more or less pure water, is worthy of all consideration. This suggestion receives still greater emphasis in the chapter on "Tuberculosis in Cattle," pages 52 to 74, which is all too short, although pregnant with information. The credit of first calling attention to this dire disease is given to Gerlach, to whom Dr. Billings has dedicated his book. The notion that pulmonary consumption may be conveyed by the milk of tuberculosis in cows is not a pleasant one. In the opinion of the reviewer, consumption is often a foul-air disease, caused quite as much, and even oftener, by inhaling foul air, as from mere exposure to cold and wet. Dr. Billings says, "In Germany, where the majority of the milch-cows are stall-fed, and that, too, in poorly-ventilated, ill-arranged, and filthy stables, this disease has acquired an extension of which we can at present make no appreciation in this country," although we have an inkling of it among swill-fed cows. Bollinger reproduced the disease in pigs, calves, lambs, and rabbits, fed on milk from tuberculous cows. Billings is undoubtedly right when he says, page 73, that "such milk does contain elements of a specifically infectious character, and there is no question that laws should be made, and executed also, to prevent the sale of such milk for human consumption, either by itself, or mixed with other milk, in no matter how small quantities. No such milk should be sold. The specific infection of milk from tuberculous cows is no trifling matter; it is one of life and death." Consumption, scrofula, and marasmus are only too common among the hundreds of thousands of babies that are yearly brought up on poor cow's milk. However important trichiniasis may be, this far exceeds it.

Every consumptive cow should be branded by expert men. Its milk can only be given with safety to swine, after being boiled; and, although the notion is not a nice one, the doctor thinks they should be fattened and killed, as the meat is not injurious when well cooked. It is to be presumed that even "the eaters of lights" will not consume the lungs of such animals, and the liver and kidneys also must be viewed with much suspicion.

THE RELATIONS OF MIND AND BRAIN. By HENRY CALDERWOOD, LL. D. New York: Macmillan & Co. Pp. 527.

THE metaphysician Sir William Hamilton, Professor of Logic in the University of Edinburgh, got embroiled in controversy with the phrenologists, and paused in his career of abstract speculation to make investigations into brain-structure, skull-measurement, and alleged "bumps" of faculty, and all for the confutation of phrenological doctrine. Another metaphysician of Edinburgh seems to have encountered a similar difficulty in his prosecution of the subject of mind. His main studies had been in the region of mental philosophy, as pursued by the old school, without especial reference to its corporeal foundations in the nervous structures of organized beings. But the modern scientific movement set so strongly in the direction of physiological inquiries, or the extension of cerebral psychology, that Dr. Calderwood found it necessary to pause, as his great predecessor had done before, and give attention to the new questions that have arisen from the study of the organic side of the subject.

Dr. Calderwood is unquestionably well imbued with the spirit of the scientific method, as is shown both by his recognition of the necessity for the systematic study of bodily conditions to any one who would ar-

rive at a true understanding of mental phenomena, and also by the systematic character and evident thoroughness of his studies in the nervous system. His volume has interest from this point of view, quite independent of any special conclusions at which he has arrived. The first edition was published in 1879, and met with so favorable a reception that he has found it desirable, from his own ripening views and from important contributions that have been recently made to the subject of animal intelligence, to revise it, and publish the second edition, which has now appeared. While Dr. Calderwood has, of course, a large appreciation of the importance of the organic factors in psychical science, it need hardly be said that he writes very much in the interest of the old mental philosophy, and against what he regards as the inordinate claims of materialistic doctrine. The object of his book, as he says, "is to ascertain what theory of mental life is warranted on strictly scientific evidence," and nothing certainly can be more significant of the progress of mental philosophy than this unreserved acceptance of the strictly scientific method in its pursuit, and the acknowledged necessity there is of studying organic derangements in connection with mental aberrations, and of studying the psychical manifestations of inferior animals, if a valid and comprehensive theory of mind is to be reached.

THE FERTILIZATION OF FLOWERS. By Professor HERMANN MÜLLER, translated and edited by D'Arcy W. Thompson, B. A. With a Preface by Charles Darwin. Illustrated. London and New York: Macmillan & Co. Pp. 669. Price, $5.

THIS comprehensive book is a collection of all the latest information upon a subject which pertains to the relations of two sciences—botany and entomology. It was not until the close of the last century that the true nature and significance of flowers began to be perceived, and we are indebted to Sprengel for the earliest true explanations of the most important phenomena in the life of flowers. From that time onward observations have accumulated and explanations multiplied until the present age, when the whole subject received a new impulse and took a new direction under the influence of the Darwinian school. Of the book before us, which is quite a cyclopædia of the subject, Mr. Darwin says in the prefatory notice, which was one of the very last of his writings:

> The publication of a translation of Hermann Müller's "Die Befruchtung der Blumen," etc., will without doubt be a great service to every English botanist or entomologist who is interested in general biological problems. The book contains an enormous mass of original observations on the fertilization of flowers, and on the part which insects play in the work, given with much clearness and illustrated with many excellent woodcuts. It includes references to everything which has been written on the subject; and in this respect the English edition will greatly exceed in value even the original German edition of 1873, as Müller has completed the references up to the present time. No one else could have done the latter work so well, as he has kept a full account of all additions to our knowledge on this subject.
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> Any one who will carefully study the present work, and then observe for himself, will be sure to make some interesting discoveries; and, as the references to all that has been observed are so complete, he will be saved the disappointment of finding that which he thought was new was an already well-known fact.

THE UNITY OF NATURE. By the DUKE OF ARGYLL. New York: G. P. Putnam's Sons. Pp. 571. Price, $2.50.

THIS work is a sequel to "The Reign of Law," published in 1866. It is of philosophical import, and devoted to the discussion of many of the most important questions and problems concerning the order and government of nature, which have come into great prominence in new forms in the present age. It is written from the orthodox stand-point, is full of acute criticisms, displays a wide familiarity with the results of science, is full of controversy, and is an elegantly printed and very handsome book—as becomes its ducal authorship.

FOR MOTHERS AND DAUGHTERS: A MANUAL OF HYGIENE FOR THE HOUSEHOLD. By Mrs. E. G. COOK, M. D. New York: Fowler & Wells. Pp. 292. Price, $1.50.

THE author has spent many years in studying the causes of the sufferings of women and trying to relieve them. Believing that they came of ignorance or violation of Nature's laws, she has composed this work to point out those laws, and direct such women as it can influence to return to them. In it are discussed, briefly, the ordinary subjects of hygiene, and the special functions

of women, and such principles are inculcated as may induce women to take care of their health, and make themselves fit for the proper and effective accomplishment of the purpose around which the objects of their life center.

AN ESSAY ON THE PHILOSOPHY OF SELF-CONSCIOUSNESS. By P. F. FITZGERALD. Cincinnati: Robert Clarke & Co. Pp. 154. Price, $1.25.

IN this essay the author has aimed to give an analysis of reason and the *rationale* of love. He believes he has made three discoveries regarding the intellectual, the affectional, and the moral nature of man: 1. "That the substance or hypostasis of thought is Being—the Being of the individual Ego being in every case the stand-point of rational judgment"; 2. That the affections or emotions are essentially correlative and reciprocal in their nature—or that attraction in the spiritual world is reciprocal and complementary; and, 3. That in the rational being, "joy of life is only completely attained through realization of the ideals of feeling, thought, and will."

HAND-BOOK OF TREE-PLANTING. By NATHANIEL H. EGLESTON. New York: D. Appleton & Co. Pp. 126. Price, 75 cents.

THE author of this "Hand-Book" will be remembered by the readers of "The Popular Science Monthly" as having contributed to it, in 1881, 1882, and 1883, a number of valuable articles on subjects relating to forestry. The present book relates to the same subject, that is, to the planting of trees in masses, and aims to meet the wants of land-owners, more especially of those whose lot is cast in portions of the country destitute, or nearly so, of trees, and who feel the need of them, but are inexperienced in their cultivation. It is divided into four parts—"Why to plant; when to plant; what to plant; and how to plant"—the questions coming under each of which heads are answered clearly and in a plain, practical, common-sense manner. The treatise, besides having the qualities just referred to, is lucid and simple in its literary construction, brief, interesting, instructive, comprehensive, and withal convenient in size for the hand or the pocket; and it offers a complete exemplification of what a manual on any practical subject for plain men ought to be.

PROTECTION TO YOUNG INDUSTRIES, AS APPLIED IN THE UNITED STATES. A Study in Economic History. By F. W. TAUSSIG, Ph. D., Instructor in Political Economy in Harvard College. New York: G. P. Putnam's Sons. Pp. 72.

THIS instructive monograph on one of the most prominent points in the political economy of protection was originally written in competition for the Toppan Prize in Political Science at Harvard University, and received that prize in October, 1882. The writer carefully examines the history of the cotton, the woolen, and the iron manufactures of this country, with reference to the influences that have been operative in their development, and the result is thus given in his concluding remarks.

> The three most important branches of industry to which protection has been applied have now been examined. It has appeared that the introduction of the cotton-manufacture took place before the era of protection, and that—looking aside from the anomalous conditions of the period of restriction from 1808 to 1815—its early progress, though perhaps somewhat promoted by the minimum duty of 1816, would hardly have been much retarded in the absence of protective duties. The manufacture of woolens received little direct assistance before it reached that stage at which it could maintain itself without help, if it were for the advantage of the country that it should be maintained. In the iron-manufacture, twenty years of heavy protection did not materially alter the proportion of home and foreign supply, and brought about no change in methods of production. It is not possible, and hardly necessary, to carry the inquiry much further. Detailed accounts can not be obtained of other industries to which protection was applied; but, so far as can be seen, the same course of events took place in them as in the three whose history we have followed. The same general conditions affected the manufactures of glass, of earthenware, of paper, of cotton-bagging, sail-duck, cordage, and other articles to which protection was applied during this time with more or less vigor. We may assume that the same general effect, or absence of effect, followed in these as in the other cases.

FEDERAL TAXATION. By SAMUEL BARNETT. Pp. 45. Richmond, Va.: Andrew Baptist & Co.

THIS pamphlet is made up of a collection of editorials which appeared in the "Atlanta Constitution." They consist of independent criticisms of our national policy in regard to taxation, expressed with great force and free-

dom. The writer places a high estimate on the value of the Federal Union, but thinks it would be worth more if it cost less. While its benefits are inexpensive, its abuses are costly. Free trade between the States, which Mr. Barnett thinks the chief advantage of the Federal Union, costs nothing; while "protection" is more expensive than the government itself. The tax policy of the Federal Government, carried on by protection, he declares to be bad in theory and even worse in practice; and that few, of even public men, have the faintest conception of how bad it is. Mr. Barnett proclaims a very important truth when he says that "nothing short of a *quantitative study* of its impositions can properly expose them; the pretty fallacies of protection melt like wax in the fire of quantitative analysis." The treatment of the several topics is rather suggestive than systematic, but the pages are full of telling facts, and many hard blows are dealt upon the system of organized corruption which shelters itself under the false pretense of protection.

"THE KANSAS CITY REVIEW OF SCIENCE AND INDUSTRY." Edited by THEODORE S. CASE. Kansas City, Mo.: Monthly, 64 pp. Price, $2.50 a year.

WITH its May number this magazine begins its eighth year. The "Review" is doing an excellent work in stimulating an interest in science in the rapidly growing country west of the Mississippi. But very few of its articles are solely of local interest; a wide range of sciences is represented in its pages, while manufactures and the arts based upon science, including education, are by no means neglected.

"THE CANADIAN RECORD OF NATURAL HISTORY AND GEOLOGY, WITH PROCEEDINGS OF THE NATURAL HISTORY SOCIETY OF MONTREAL." Vol. I, No. 1. J. T. DONALD, M. A., Editor. Montreal, January, 1884.

THIS magazine takes the place of "The Canadian Naturalist," until last June published for the above-named society by the Messrs. Dawson Brothers. The "Record" is to be published quarterly, and, in addition to the society's proceedings, will contain original papers on scientific subjects by Canadians, and reprints of scientific papers of merit published elsewhere, which deal with Canadian subjects. The first number contains a report of the second annual meeting of the Royal Society of Canada, held at Ottawa in May, 1883; two short papers on geological subjects, by Principal J. W. Dawson; and an extended account of "The Athabasca District of the Canadian Northwest Territory," by the Rev. Émile Petitot. There are also three short papers by the editor, and part of a memorial address on the late James Richardson.

A TEXT-BOOK OF INORGANIC CHEMISTRY. By Professor VICTOR VON RICHTER, University of Breslau. Translated by Edgar F. Smith, A. M., Ph. D. Philadelphia: P. Blakiston, Son & Co. Pp. 424. Price, $2.

PROFESSOR VON RICHTER'S treatment of his subject is characterized by an effort to show how the possession of a few facts leads to the formation of scientific theories, and the theories in turn show the investigator where to look for new facts. "The Periodic System of the Elements," or "Mendelejeff's Table," is made the basis of the work, and considerable attention is given to thermo-chemical phenomena, the periodicity of which is brought prominently forward. There is a short chapter on "Crystallography," with diagrams, and one on "Spectrum Analysis." The volume is illustrated with a colored plate of spectra, and eighty-nine woodcuts.

PUBLICATIONS RECEIVED.

The Past and the Present of Political Economy. By Richard T. Ely, Ph. D. Baltimore: N. Murray. Pp. 64.

"The Journal of Physiology." Vol. V, No. 1. Edited by Michael Foster, M. D. Baltimore: N. Murray. Pp. xii–484. $5 a year.

An Investigation locating the Strongest of the Bronzes. By W. H. Ernest H. Jobbins, M. E. Pp. 48.

Aneurism of the Femoral Artery, and a Knife-Wound of the Intestines. By W. O. Roberts, M. D. Louisville, Ky. Pp. 11.

Esplorazione di un Shell-mound Indiano presso Nueva Orleans, Luisiana. (Exploration of a Shell-Mound near New Orleans, La.) By R. W. Shufeldt, U. S. Army. Florence, Italy. Pp. 11.

Studies from the Biological Laboratory of Johns Hopkins University. H. Newell Martin, D. Sc., and W. K. Brooks, Ph. D., Editors. Baltimore: N. Murray. Pp. 48, with Six Plates. 70 cents.

The Glacial Boundary in Ohio, Indiana, and Kentucky. By Professor G. Frederick Wright. Cleveland, Ohio: Western Reserve Historical Society. Pp. 86.

The Determination of the Flashing Point of Petroleum. By John T. Stoddard. Pp. 6.

What and Why. By Charles E. Pratt. Boston: Pope Manufacturing Company. Pp. 72.

The Mormon Question. By J. W. Stillman. Boston: J. P. Mendum. Pp. 40.

Massachusetts Agricultural College, Report for 1883. Boston: Wright & Potter Printing Company. Pp. 73.

Sanitary Drainage of Tenement-Houses. By William Paul Gerhard, C. E. Hartford: Cox, Lockwood, and Brainard Company. Pp. 40.

Methods of Historical Study. By Herbert B. Adams, Ph. D. Baltimore: N. Murray. Pp. 136. 50 cents.

The Postal Telegraph. Speech by Hon. John A. Anderson, of Kansas. Washington. Pp. 23.

Notes on the Literature of Explosives. By Professor Charles E. Munroe, U. S. N. A. Pp. 29.

"Home Science Monthly." Vol. I, No. 1. New York: Selden R. Hopkins. Pp. 112. $2.50 a year.

Memoirs of the Boston Society of Natural History (Carboniferous Myriapods and Cockroaches). By Samuel H. Scudder. Boston: Published by the Society. Pp. 27, with Two Plates.

Reports on the Cotton Production: Of the State of Texas. Pp. 173. In the Indian Territory. Pp. 84. Of the State of Arkansas. Pp. 116. By R. H. Loughridge, Ph. D. Berkeley, Cal.: From the Tenth Census Report.

Der freie Wehrman als Träger der darwinischen Sittlichkeit und sozial Reform. (The Free Warrior as a Pillar of Darwinian Morality and Social Reform.) By John H. Becker. Berlin.

Katy Neal: A Comedy of Child-Life. By Charles Bernard. New York: Harold Roorbach. Pp. 46. 15 cents.

The American University. By Professor John W. Burgess, Ph. D. Boston: Ginn, Heath & Co. Pp. 22. 15 cents.

Fertilizers: Greensand Marl. By Dr. C. A. Greene. Harrisburg, Pa. Pp. 29.

Real and Imaginary Effects of Intemperance. By G. Thomann. New York: United States Brewers' Association. Pp. 167.

The Necessity of an Ambulance System in Chicago. By G. Frank Lydston, M. D. Chicago: A. G. Newell. Pp. 8.

Modern Sanitation. By G. Frank Lydston, M. D. Chicago: A. G. Newell. Pp. 23.

Geological Survey of New Jersey. Report for 1883. By George H. Cook, State Geologist. Pp. 188.

Q. P. Index Annual, 1883. Bangor, Me.: Q. P. Index, Publisher. Pp. 36.

History of the Discovery of the Circulation of the Blood. By Henry C. Chapman, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 56. $1.

The Parlor Muse. New York: D. Appleton & Co. Pp. 96. 30 cents.

English as She is Spoke: With an Introduction by James Millington. New York: G. P. Putnam's Sons. Pp. 56. 50 cents.

Beginnings with the Microscope. By Walter P. Manton, M. D. Boston: Lee & Shepard. Pp. 73. 50 cents.

Trafalgar: A Tale. By Perez Galdos. From the Spanish by Clara Bell. New York: W. S. Gottsberger. Pp. 255.

Lectures on Light. By G. G. Stokes, F. R. S. London: Macmillan & Co. Pp. 133. 75 cents.

Systematic and Descriptive Mineralogy. By J. H. Collins, F. G. S. New York: G. P. Putnam's Sons. Pp. 229. $1.25.

The Clew of the Maze and the Spare Half-Hour. By the Rev. Charles H. Spurgeon. New York: Funk & Wagnalls. Pp. 190. 75 cents.

"Science Ladders." Nos. 1 to 6. By N. D'Anvers. New York: G. P. Putnam's Sons. Pp. about 400. $1.50.

Brain-Exhaustion. By J. Leonard Corning, M. D. New York: D. Appleton & Co. Pp. 234. $2.

The Consolations of Science. By Jacob Straub. Chicago: The Colegrove Book Company. Pp. 435.

The Outskirts of Physical Science. By T. Nelson Dale. Boston: Lee & Shepard. Pp. 187. $1.25.

Six Centuries of Work and Wages. By James E. Thorold Rogers, M. P. New York: G. P. Putnam's Sons. Pp. 591.

The True Theory of the Sun. By Thomas Bassnett. New York: G. P. Putnam's Sons. Pp. 263. $3.

"The Globe Pronouncing Gazetteer." Edinburgh: Oliver & Boyd; New York: G. P. Putnam's Sons. Pp. 462, with 32 Maps.

Sorghum: Its Culture and Manufacture economically considered. By Peter Collier, Ph. D. Cincinnati: Robert Clarke & Co. Pp. 582. $3.

Machinery of the Heavens. By A. P. Pichereau. Galesburg, Ill.: The Author. Pp. 142. $1.50.

In the Heart of Africa. By Sir Samuel W. Baker; condensed by E. J. W. New York: Funk & Wagnalls. Pp. 286. $1.

Pine Needles, or Sonnets and Songs. By Heloise Durant. New York: G. P. Putnam's Sons. 1884. Pp. 160.

Geology and Mineral Resources of the James River Valley, Virginia. By J. L. Campbell, LL. D. New York: G. P. Putnam's Sons. Pp. 119. $1.

The Woman Question in Europe. Edited by Theodore Stanton. New York: G. P. Putnam's Sons. Pp. 478. $3.50.

Report of the Commissioner of Agriculture for 1883. Washington: Government Printing-Office. Pp. 496.

Mental Evolution in Animals. By George John Romanes, F. R. S. New York: D. Appleton & Co. Pp. 411. $2.

A Graveyard Flower. By Wilhelmine von Hillern. From the German, by Clara Bell. New York: William S. Gottsberger. Pp. 160.

A Manual of Psychological Medicine and Allied Nervous Diseases. By Edward C. Mann, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 699. $5.

POPULAR MISCELLANY.

The British Association.—The British Association will meet in its fifty-fourth annual session at Montreal, August 27th, under the presidency of Lord Rayleigh. The Vice-Presidents will be the Governor-General of Canada (Lord Lansdowne), Sir John A. Macdonald, Sir Lyon Playfair, Sir Alexander T. Galt, Sir Charles Tupper, Sir Narcisse Dorion, Hon. Dr. Chauveau, Principal J. W. Dawson, Professor Edward Frankland, Dr. W. H. Hingston, and Dr. T. Sterry Hunt. Professor A. W. Williamson will be General Treasurer; Captain Douglas Galton and A. G. Vernon Harcourt, General Secretaries; Professor T. G. Bonney, Secretary; L. E. Dawson, R. A. Ramsay, S. Rivard, S. C. Stevenson, and Thomas White, M. P., Local Secretaries; and Mr. F. Wolferstan Thomas, Local Treasurer. The Presidents of the Sections will be: A, Mathematical and Physical Science, Sir William Thomson; B, Chemical Science, Professor H. E. Roscoe; C, Ge-

ology, W. T. Blanford; D, Biology, Professor H. N. Moseley; E, Geography, Colonel Rhodes and P. L. Sclater, Vice-Presidents; F, Economic Science and Statistics, Sir R. Temple; G, Mechanical Science, Sir F. J. Bramwell; H, Anthropology, Professor E. B. Tylor. It is expected that the public lectures will be by Mr. Crookes, Dr. Dallinger, and Professor Ball. The special discussions will be: Friday, August 29th, "The Seat of the Electro-motive Forces in the Voltaic Cell"; and Monday, September 1st, "The Connection of Sun-Spots with Terrestrial Phenomena." Most liberal provisions have been made by the Canadians for the accommodation and entertainment of their guests. The expenses of fifty officers are guaranteed; the Dominion Parliament has appropriated $14,000 toward the expenses of ordinary members; the steamship companies have made considerable reductions of fares; members of the Association are invited to bring their wives and two near relatives with them; the Canadian Pacific Railway offers free excursions to one hundred and fifty members from August 1st till the grand excursion to the Rocky Mountains; and other excursions have been provided for or are contemplated, among which is the excursion to the American Association, which meets in Philadelphia, September 3d.

Death of Professor Klinkerfues. — Professor C. A. Eggert, of the University of Iowa, has kindly furnished us with the following facts respecting the life and work of Professor F. W. Klinkerfues, of the University of Göttingen, one of the most prominent astronomers in Germany, who died by suicide—provoked, it is supposed, by pecuniary losses and excessive use of intoxicating liquors—on the 28th of January last: Professor Klinkerfues was born at Hofgeismar in 1827, and very early manifested a decided taste for astronomical studies. He became a pupil of Gauss, who recognized his very remarkable mathematical talents. Some of his earlier efforts were afterward incorporated, with but little change, in his "Theoretical Astronomy," a work of decided merit. Two of them deserve special mention: one, a new method of calculating the course of a comet from one incomplete and two complete observations; and the other, for the computation of the orbits of double stars. His hypothetical method for the determination of the distance of certain fixed stars belonging to the same system was applied with a satisfactory result to Sirius. Other of his hypothetical combinations were bold and successful in a high degree. Thus, he predicted a close relation between the meteoric shower of November 27, 1872, from the constellations Perseus and Andromeda, and Biela's comet, and that the comet would be found in the opposite quarter of the sky. He telegraphed to the director of the observatory in Madras: "Biela's comet has touched the earth. Look for it in Centaur, near the star ϑ." The comet was found at the spot indicated. Professor Klinkerfues was the discoverer of comets III, 1853; III, IV, 1854; III, 1857; V, 1857, and II, 1863. He was best known in Germany for his predictions of the weather, which he based on the hygrometric indications of moisture in the air. Their fault was, that they depended on the indications at the surface, while the weather goes by the proportion of moisture in the upper strata of the atmosphere, which may be very different. His instrument, known as the Klinkerfues hygrometer, met with considerable success for a time, but was ultimately found to be of little practical value, and is not much used now. Although Professor Klinkerfues was no more successful in other points as a weather-prophet, he has enriched meteorology with observations and facts of some importance; and it would be unjust to classify him with the noisy charlatans whom our newspapers hoist into temporary fame. Notwithstanding his mistakes, the death of such a man is a loss to science. Supplemented by careful observations, his hypotheses on astronomical matters often approached mathematical certainty, and it is not easy to say how much he might yet have accomplished but for the abrupt and melancholy closing of his career.

Facts about British Stature.—The Anthropometric Committee of the British Association, after several years of labor, made its final report at the recent meeting of that body. The committee was appointed for the purpose of "collecting observations in

the systematic examination of the height, weight, and other physical characters of the inhabitants of the British Isles," and, in performing its work, took all sorts of measurements of people of all classes, of all ages, and of both sexes, living in all parts of Great Britain, and, to a small extent, of persons living in Ireland. The measurements or observations covered twelve points by which man is externally distinguished from man, and were made upon thousands of people. We notice a few of the more striking results: In average height, the Scotch stand first (68·61 inches), the Irish second, the English third, and the Welsh fourth, while in weight, the Scotch still leading with 165·3 pounds, the Welsh are second, the English third, and the Irish fourth. In the light of these two results, the London "Times" observes that the Scot will look upon the discovery made by the committee "as simply giving the hall-mark of science to his own instinctive conviction that he is a much better man in all respects than the 'fausse southron.'" As between the sexes in England, the average stature of adult males is 67·36 inches, and that of adult females 62·65 inches, while the average Englishman weighs 155 pounds, and the Englishwoman 122·8 pounds. In strength, the Englishman can draw a bow with a power of 77½ pounds, while the woman brings to bear a force 35 pounds less, or a little more than half as much. In complexion, the lighter shades rule over the country as a whole, but a large percentage of dark complexions stretch in a band across the center of England and Wales. The inhabitants of the more elevated districts appear to possess a greater stature than those of the alluvial plains, and those of the northern and colder districts than those of the southern and warmer parts of the island; those of the northeastern and drier regions are taller than those of southwestern and damper climates. A comparison with American army statistics does not show that the Anglo-Saxon race reaches a higher stature here than in England, as some have claimed, but that a close correspondence prevails between the two groups. Compared with other nationalities in stature, except as to a few extraordinarily tall Polynesians, the English professional class head the list, and the Anglo-Saxon race takes the chief place among civilized communities, though it might stand second to the Scandinavian countries if a fair sample of their population could be obtained. Other general facts deduced from the examinations, as true in the British Isles at least, are that an open-air country life is more favorable to height and weight than a sedentary town life; that favorable hygienic and sanitary conditions have a marked influence on growth and weight; that lunatics show a deficiency of weight and stature, and criminals a greater one, indicating a lack of physical as well as mental stamina in both these classes; that athletes appear a little taller than the general population, and not as heavy; that growth diminishes, as we descend in the social scale, to a difference of five inches between the average stature of the best and most nurtured classes of children of corresponding ages, and of three and a half inches in adults. The population of the manufacturing towns do not appear to be degenerating, but exhibit a slight but uniform increase in stature, and a large increase in weight.

Darwinism in the Talmud.—Dr. B. Placzek, of Brünn, has collected citations from the Talmud to show that the old Jewish writers were keen observers of Nature, and had ideas akin to Darwinism. Joseph Albo, in the fifteenth century, suggested the thought of compensation, or interchange of relations, in an hypothesis that cattle are defective in teeth because so much of the tooth-stuff goes to horn, and that they make up for the resultant deficiency in their powers of mastication by the faculty of chewing the cud. Other writers noticed that the integrity of the comb of the cock had much to do with its masculine potency, and that other birds suffer in spirit and vigor when deprived of their ornamental appendages. A writer in the "Agada" affirmed, in justification of Solomon's selection of the ant as an example of wise industry, that it builds its houses in three stories, and stores its provisions, not in the upper compartment, where they may be rained on, nor in the lower, where they will gather dampness, but in the middle one, the safest place, and that it gathers all it can. The ant is also

a fit type of honesty, for it regards the property of its neighbors, and will not rob. Once, it is said, when an ant dropped a grain of corn, a number of other ants came up and smelled of it, but let it lie till the owner came up and took it away. Simon ben Chalafta, "the Experimenter," tells of an experiment worthy of Lubbock. On a very hot day he put a cover over an ant-hill. A sentry ant came out, observed the shadow, and reported upon it to his fellows. They came out to enjoy the coolness of the shade, when it was suddenly taken away, and the insects, irritated by the burning sun, fell upon the scout that had led them into the trap, and killed him. The Agadists make much of the devotion of the individual ant to the welfare of the whole colony as a salient point of formic character. Dr. Placzek suggests that Solomon may have been acquainted with a kind of agricultural ants from his sentence, "Provideth her meat in the summer, and gathereth her food in the harvest," where the former verb may, in analogy with other cases of its use in the Bible, refer to the preparation of the field. Passages are quoted that point to the thought that the difference in mental gifts between men and animals is only quantitative. In one of the books, a limit is set to the scope of scientific investigation thus: "What is too high for thee, seek not to reach; what is too hard for thee, seek not to penetrate; what is incomprehensible to thee, try not to know; what remains hidden from thy mind, strive not to discover. Direct thy thought only to what is attainable, and trouble thyself not about hidden things."

Geological Catastrophes.—The Duke of Argyll, in his address to the Edinburgh Geological Society, on its fiftieth anniversary, took the ground that "nothing can be more unphilosophical than the antithesis and opposition which is set up between what is called the law of continuity and what is called the doctrine of catastrophes. Throughout all Nature, and throughout all those operations of the human intellect which depend on the manipulation of natural forces, we see the two doctrines to be perfectly harmonious—strains and tensions maintaining themselves in absolute silence up to the bending or the breaking-point—pressures pressing with tremendous but noiseless energy up to the bursting point—and then moments of rapid and sometimes of instantaneous change. If it is irrational to quote the continuity of Nature as affording any, even the least, presumption against sudden and great effects, it is still more irrational to quote it as irreconcilable with effects which, though catastrophes to us, whose scales of measurement are often the scales of pygmies, are in reality nothing but movements of infinitesimal smallness in the scale of Nature. I had occasion the other day, in delivering a popular lecture in Glasgow, to exhibit a section of the globe drawn to the scale of one tenth of an inch to a mile. On that scale, which I have taken from my friend Mr. James Nasmyth, the globe is represented by a circle sixty-four feet in diameter, and I was able to show that on that portion of the curve which represents one eighth of the circumference, the elevation of the highest mountain in Europe, Mont Blanc, was wholly invisible to the spectators who were half-way down the hall, and could barely be seen even by those who were close at hand. The truth is, that, when we come to realize the almost infinitesimal smallness of the irregularities of the earth's surface as compared with its circumference—the whole range from the highest height to the deepest deep being somewhat less than sixty thousand feet—the wonder comes to be that if subterranean forces are at work at all in modifying, from time to time, the perfect smoothness and sphericity of the surface, not that their work should be so great, but, on the contrary, that it should be so very small."

Causes of Typhoid Fever.—In a paper published by the Iowa State Board of Health on the nature, causes, and prevention of the typhoid fever of America, Dr. R. J. Farquharson, Secretary of the Board, emphasizes the distinction between typhus and typhoid, an important point of which is, he believes, that typhoid is not contagious. A number of reports, American and foreign, seem to concur in fixing the origin of the disease in some condition of the ground or water, and indicate that it may be produced by foul water, by foul air, or by emanations from

the earth, occurring most frequently in the autumn and during seasons of drought. It has sometimes been traced with every evidence of probability to decayed wood, and this indicates that vegetable decay is one of the prime sources of its origin—a view which the fact that it has been produced by the drying of ponds does not contradict, but rather supports. A direct connection is traced, in the United States, between the increase of summer temperature and this disease. The curves of normal temperature, of typhoid fever, and of malarial fevers are almost exactly parallel, except that the culmination of the fever curve, in September for Iowa, October for the Eastern States, is behind that of the temperature curve, which occurs in July. A general parallelism, but without the uniformity of the culminating point of fever, has, with the exception of one spot (Munich), been observed in Europe. Since the disease is not contagious, the minute directions for isolation, disinfection, destruction of clothing, etc., so eminently proper in really contagious diseases, are useless in typhoid fever. In our present knowledge of the causes of the disease, but little can be done, and that only in a general way, to prevent it. The principal points are to see that the drinking-water is pure, that the house is well ventilated and not built over a marshy spot, that slops are removed far enough away, and that the drains are kept clean and washed and are occasionally disinfected with copperas; and, when sickness occurs, the patient should be given quiet and plenty of fresh air.

The Weather and Neuralgia.—The case of Captain R. Catlin, United States Army, as reported by Dr. S. Weir Mitchell, affords a curious illustration of a relation between neuralgic pains and meteorological condition. Captain Catlin had his foot crushed by a round shot in August, 1864. His leg was amputated below the knee. Pain was felt early as if in the lost foot, and became severe within nine months, while in other respects Captain Catlin is and has been in perfect health. Since 1871, the captain has kept a regular record of the hours of pain he suffered each year and each month. The maximum of pain was attained in 1874 and 1875. During 1876 the amount of pain fell off 100 hours (from 1,892 to 1,790), with a decrease of mean annual pressure and a corresponding increase of temperature. For 1877, pain and pressure remained constant and parallel, with some increase in temperature. In 1878 the pain decreased 200 hours, while an equally remarkable fall was shown in the barometric curve. The law of relationship of low pressure and high temperature to the amount of pain and the number of attacks of pain and the number of storms becomes more apparent in considering the quarterly and monthly distribution of pain and storm. "The winter months hold the advantage as pain-producers," while in quarterly amounts the first quarter, beginning with the winter solstice, leads; the fourth quarter, ending with the winter solstice, follows; and the second, or spring quarter, is next. In months, March holds the lead, and is closely pressed by January, after which follow November, December, May, February, April, August, October, September, July, and June. The average duration of each attack of pain during eight years was 18·97 hours. The duration also bears a relation to the amount of pain and the number of storms, and is greatest in February. To determine the average distance of the storm-center at the beginning of the pain-attack, sixty well-defined storms through ten consecutive months were taken. The average distance was six hundred and eighty miles, the particular distances ranging from two hundred to twelve hundred miles. It has been observed that eating a meal, when the pain is on, intensifies it, and it is believed that it often hastens the attack. During seven years (1875 to 1882) nine neuralgic attacks of great and unusual power were observed, and a coincidence was traced between them and storms of extraordinary intensity. The best regimen for this neuralgic subject has been found to consist in physical exercise, nutritious food, and light, agreeable occupation.

Dr. Michael Foster on School Examinations.—Dr. Michael Foster, in a recent address before a pharmaceutical school in London, gave a vigorous expression to his views respecting examinations. The passing of an examination was regarded as a mark, stamp, or certificate, of what? He ventured to

think that success in this sphere of action merely indicated that the prize-man had the ability and skill to get on in an examination. No doubt a stupid and idle man could not get first places in examinations, and so the industrious and clever were picked out by the process. But it was certainly not the case that those who failed to get the highest honors in examinations went to the wall in after-life. On the contrary, he was sorry to say that he knew some who had succeeded to the fullest extent during the examinational period of their life, yet did not maintain their prestige as time rolled on. And not a few men who were signal failures at examinations have proved of enormous value in after-years. To some a vast amount of evil was wrought from the fact that no proper knowledge had been acquired to pass the standard. He advocated a plan of examination which is partly carried out at the School of Science, South Kensington. That was, to study and be examined on each subject separately, and by the same persons who had acted as teachers.

The Future of Physiological Experiment.—Professor Tyndall founds a new argument in favor of the practice of experimental physiology in the peculiar properties of infectious diseases, and their probable germ origin. One of the most extraordinary and unaccountable experiences in medicine has been the immunity secured by a single attack of a communicable disease against future attacks of the same malady. Small-pox, typhoid, and scarlatina, have been found, for example, as a general rule, to occur only once in the lifetime of the individual, the successful passage through the disorder seeming to render the body invulnerable against future attacks. Professor Tyndall had some time ago suggested to a friend that the phenomenon could be explained under the germ theory by supposing the soil, or the system, to be exhausted by the first parasitic crop, of some ingredient necessary to the growth and propagation of the parasite. Some important essays on the subject have been recently published in the "Revue Scientifique" by M. Bouley, who draws attention to the results obtained by M. Raulin in the cultivation of the microscopic plant *Aspergillus niger*. The omission of potash from M. Raulin's liquid suffices to make the produce fall to one twenty-fifth of the amount collected when potash is present. The addition of an infinitesimal amount of a substance inimical to the life of a plant is attended with still more striking results. For example, one part in 1,600,000 of nitrate of silver added to the liquid entirely stops the growth of the plant. Now, supposing the aspergillus to be a human parasite—a living contagium—capable of self-multiplication in the human blood, and of so altering the constitution of that liquid as to produce death; then, the introduction into the blood of a man weighing sixty kilogrammes, of five milligrammes of nitrate of silver would insure, if not the total effacement of this contagium, at all events the neutralization of its power to destroy life. An index-finger here points out to us the direction which physiological experiment is likely to take in the future. In anticipation of the assault of infectious organisms, the experimenter will try to introduce into the body substances which, small in amount, shall so affect the blood and tissues as to render them unfit for the development of the contagium. And, subsequent to the assault of the parasite, he will seek to introduce substances which shall effectually stop its multiplication. Dr. Polli, of Milan, has already obtained results that promise well with alkaline sulphides in certain fevers and small-pox, and Crudelli obtained similar results with arsenic against the malaria of the Roman Campagna. To enable us to administer these remedies safely and with some assurances of success, experiments must be made of their effects, on different groups of individuals, and these individuals must be animals susceptible to the infection and to the counteracting application. "I appeal," says Professor Tyndall, "not to the partisans of either side, but to the common sense of England, whether, in the interests of humanity, the proposed experiment is not a legitimate one."

Effect of School-Work on the Brain.—A question was recently asked Mr. Mundella, in the British House of Commons, as to the effect of the English educational system on the health of children and teachers. He replied in substance, availing himself of the reports of the Lunacy Commissioners,

that the effect of education had been, even in the midst of a rapidly-increasing population, to diminish the absolute number of children admitted to asylums. So, of the group described as teachers, schoolmasters, schoolmistresses, governesses, professors, and lecturers, the proportion admitted to asylums was less than that of any other profession. This statement should dispose of much of what is said about the ordinary routine of school occupation leading to mental disease. While pupils who are stimulated or pressed, by cramming, to over-exertion may suffer injury, a lively exercise of the mental faculties on some varieties of subjects, which is the most that the majority of school-children attain, is more likely to be promotive of vigor. The fact that insanity prevails most among agricultural laborers in the rural counties, where the standard of education is lowest, and mental vacancy is least interrupted, tends to show that absolute blankness of mind, like the non-use of a physical faculty, promotes disease. So with teachers: while the demands on their brains are constant and call for vigorous exercise, they are, as a rule, seldom of a kind to involve overwhelming pressure, or so irregular as to admit of intervals when the mind is wholly unemployed and liable to morbid reaction.

Poisons developed in the Body. — On this subject Dr. Benjamin W. Richardson says: "In my reports to the British Association for the Advancement of Science, I have pointed out that the substance *amylene*, an organic product which can be easily constructed in vital chemical changes, produces phenomena identical with those of somnambulism and with some of the phenomena of hysteria. I have pointed out, in the same reports, that another organic product, called *mercaptan* (sulphur-alcohol), causes, when inhaled, symptoms of profoundest melancholy, and that, in the process of being eliminated by the breath, it gives to the breath an odor which is identical with the odor evolved in the breaths of many patients who are suffering from the disease called melancholia. From these observations I have ventured to suggest that various forms of mental affection and of nervous affection depend for their development on the presence in the body of organic chemical compounds, formed and distilled through an unnatural chemical process carried on in the body itself. I have endeavored to develop this subject somewhat further by my researches on the action of lactic acid on animal bodies. I have shown by experiment that this acid, diffused through the body by the blood, acts as a direct irritant upon the lining membrane of the heart, the *endocardium*, and all the fibro-serous membranes of the body, so that a synthesis of heart-disease and rheumatism can be established by its means. Lactic acid is the most copious product thrown out in the disease called rheumatic fever, and, as many of the phenomena resulting from that disease take the same form and character as those producible by lactic acid, I infer from the best evidence attainable that this acid, the product of a fermentative change going on in the body during acute rheumatism, is the cause of the secondary structural affections which so frequently follow acute rheumatism. It has been for some time past observed by several able physicians that persons who are suffering from the affection known as diabetes give off a peculiar odor from their breath—an odor which to some is like that of vinegar, to others of sour beer, to others of a mixture of ether and chloroform, to others of acetic ether. I should compare it myself to the odor of grains as it is detected in a brewery. When this odor is observed in the breath of diabetic patients, it frequently happens that they become sleepy, cold, and unconscious, with the results of coma and death. At one time it was supposed that these phenomena were uræmic, and were due to the presence of urea in the blood; but the absence of convulsion and of some other symptoms destroys this hypothesis, or at all events shakes it. It is now believed that the symptoms owe their origin to the decomposition of the diabetic sugar which is in the body, and to the production from that decomposition of a volatile ethereal fluid called *acetone*, a fluid which has been discovered in the blood and secretions of these affected persons, who are said therefore to be suffering from the disease 'acetonæmia.' From the action of acetone upon animal bodies

I infer that the theory of acetonæmia is founded on good evidence." Dr. Richardson mentions also the secondary absorption of poisonous matter from wounds, and from the abraded and ulcerating surfaces produced in diphtheria, malignant scarlet fever, etc., and concludes by saying: "Such observations as have been noticed under this short head lead to a study of another new point, namely, the possibility of the formation of organic alkaloids in the body during some conditions of disease. Scientific discovery has not, however, advanced so far as to enable me at this moment to do more than allude to one of the newest and most important studies in modern medical research."

Mechanism of Plant-Contraction.—Dr. J. Burdon-Sanderson, in a lecture before the Royal Institution of Great Britain, performed an experimental demonstration of the causes and phenomena of the excitability of plants. The number of plants which exhibit what is often called irritability is very considerable, but the illustrations of the lecture were drawn chiefly from typical specimens of only a few of the most familiar kinds, such as mimosa, dionea, and two or three others. The mimosa presents nearly the same appearance when asleep as when excited, but is then liable to a further change, by the operation of which it sinks to a still lower position and becomes limp. The excitatory effect is dependent on a vital change in the protoplasm of the cells, which may be observed when the plant is asleep as well as when it is awake. The cells of the plant, which unexcited are distended or charged with liquid, undergo on excitation a sudden diminution of tension or of expansion by the discharge of the water contained in them, which finds its way first into the intercellular air-spaces, and then out of the motor organ altogether. The discharge is due to a sudden loss of its water-absorbing power by the protoplasm of the cell, whereby the external cell-sac, whose elastic tendency to contract is kept in check only by the constantly distending action of the protoplasm, presses upon it with force enough to squeeze out the cell-contents. This action being participated in by all the individual cells, the leaf-stalk, or whatever organ it may be that droops, necessarily becomes limp and falls. The motion of the leaf is, however "the result of the action of many hundred independent cells, all of which may act together, but may not. In either case they take a great deal longer to think about it; for during a period after excitation, which amounts at ordinary summer temperature to about a second, the leaf remains absolutely motionless." During this interval an electrical disturbance takes place in the plant, the character and operation of which were neatly shown by the aid of some extremely delicate apparatus. Obvious and well-marked differences were pointed out between the mechanism of plant motion and that of animal motion; but the differences are not essential, for they depend not on difference of quality between the fundamental chemical processes of plant and animal protoplasm, but merely on differences of rate or intensity. "Both in the plant and in the animal, work springs out of the chemical transformation of material, but in the plant the process is relatively so slow that it must necessarily store up energy, not in the form of chemical compounds capable of producing work by their disintegration, but in the mechanical tension of elastic membranes. The plant-cell uses its material *continually* in tightening springs which it has the power of letting off at any required moment by virtue of that wonderful property of excitability which we have been studying. Animal contractile protoplasm, and particularly that of muscle, does work only when required, and, in doing so, uses its material directly."

Origin of Winding River-Beds.—Major Stevanovics, a Hungarian officer, has published an essay on the laws by which the "wash" and meandering of rivers are regulated. Based on studies of the Theiss and the Danube, the principles he elucidates are illustrated in the windings of rivers the world over, with such variations only as differences in situations and exposures might occasion. The deviations which rivers are constantly making in their course are, it appears, determined by fixed laws, which engineers should be competent to find out and regard. To understand them more fully,

we may imagine our river straight, evenly broad and deep, with no marked channel, and without tributaries. The formation of a channel begins as soon as a bit of the earthy constituents contained in the water is deposited on the ground under it. This causes an unequal distribution of the weight of the water, and a stronger inclination toward one or the other edge. The deposit slowly grows, and a sand-bar is formed, which presses the current over toward one side and gives it an angular direction. This causes it to strike with more force against one of the shores, and to wash it, eat it away, or undermine it, equally whether it be of earth or stone. Should there be a tributary coming in from the opposite side of the sand-bar, that will occasion the formation of a second bar, and this will cause the current to make another turn and render its course serpentine. In this way a system of bars is formed, that are represented in the course of time by dry alluvial deposits, from which the river has been constantly pushed to one side. Many of the peculiarities of African and other rivers may be explained by reference to these principles. The great bends of the Congo and the Niger may be accounted for by supposing that the hills that run parallel to their courses were weathered most on the side most exposed to the sun so as to cause a constant growth of the bars on the north side and a gradual pushing of the stream toward the equator. In Hungary, the courses of the streams are modified by the operation of another force, that of the equinoctial winds called the *koschava*, which blow in the spring and fall for days at a time from the southeast. The waves are driven by the wind, especially at the time of high water in the spring, with more force against the western bank, and make longitudinal excavations in it at the level of the water. After the retiring of the flood, the overhanging bank gives way and slides into the river, with a noise which is quite familiar to the people, and well understood by them. These excavations, extended and deepened by subsequent operations of the same kind, result in the formation of large bends; and the river has become very serpentine, with numerous narrow peninsulas jutting out at right angles to its current. Finally, the peninsulas are cut through and formed into islands, to become in time, as has been the case in some instances, by the operation of continued changes of the stream, a part of the other bank. Observations of this kind have been made in the Danube, and the phenomena accounted for by them are familiar on other rivers. Changes by another kind of process are caused by the fall equinoctial winds, which, instead of finding high water in their way, take up the dry sand and deposit it in drifts where they will exercise a modifying influence on the course of the river. The changes that have taken place in the Amou-Darya of Turkistan, under which its course has been diverted from the Caspian Sea to the Sea of Aral, are probably effects of an agency of this kind.

Russian Scientific Societies.—Science is promoted in Russia by several societies that are very active in their respective fields of investigations, and which have earned for their country a respectable place among the nations where knowledge is diligently and intelligently cultivated. The Kiev Society of Naturalists was formed in 1869, and is supported by a considerable membership. Its chief aim has been the exploration of the natural history of the neighboring provinces. Its published "Transactions" bear evidence of good work done in geology, zoölogy, botany, and kindred sciences. Since 1873 it has undertaken the yearly publication of a systematic catalogue of papers in mathematics, pure and applied, natural science, and medicine, printed in the numerous scientific publications of the empire. The East Siberian branch of the Russian Geographical Society, having already contributed largely to the purely geographical exploration of the unknown parts of Siberia and the adjacent countries, has now become engaged upon a more thorough scientific exploration of Siberia itself. Among its later publications is an excellent geological map of the coasts of Lake Baikal. The Siberian branch of the Geographical Society has within the last few years taken a lively interest in anthropology and archæology, and has been the means of making known many valuable discoveries in these branches. It has also paid much attention

to the meteorology of Siberia, has taken regular observations at meteorological stations, and has collected materials for ascertaining the dates of the freezing and breaking up of the ice in the rivers of the country.

NOTES.

CONCERNING the statement that Mr. Herbert Spencer is going around the world by way of Australia and San Francisco, he thus writes to an American friend: "The rumor you indicate respecting my voyage to Australia and New Zealand is all nonsense, as you suspected. Last summer I had a letter from Sir George Gray (late Governor of New Zealand), pressing me to go and stay with him, and promising great benefit to my health. My reply was that the probable result of yielding to his pressure would be that I should be left in mid-Atlantic with a cannon-shot at my feet."

MR. CHARLES DIMITRY, of New Orleans, some two years ago proposed an hypothesis that the mounds and earthworks in the Western river-bottoms were intended for places of refuge for the people and their stock in time of high water and floods. His theory received some striking illustrations during the recent expedition of the relief-steamer Tensas to the flooded districts of Red River. The water was found rushing through the crevasses with a loud noise. Trinity was completely submerged, and at Troy the situation was but little better. With the exception of a few buildings erected upon mounds (among the largest mounds in the United States), all had succumbed to the water. The graveyard on one of the mounds had become a rendezvous for stock, pigs, sheep, and human beings. At Lamarque, in Concordia Parish, where the water stood six feet deep, the stock were cared for on mounds or in houses.

THE American Ornithologists' Union has undertaken to ascertain the true character of the European house-sparrow, which has now become so abundant in this country, and of the effect of its presence upon agricultural and economical interests. It has prepared a circular of inquiries to be sent out to intelligent persons who will undertake the observations, the tenor of the answers to which, it is hoped, will determine whether the bird is eligible or ineligible as a naturalized citizen of our land. The more important of the questions bear chiefly upon the nature of the sparrow's food, the effect of its presence upon useful birds and beneficial as well as deleterious insects, and its effects on shade, fruit, and ornamental trees, and garden fruits and vegetables. Persons interested in the subject may communicate with the chairman of the association's committee, Dr. J. B. Holder, American Museum of Natural History, Central Park, New York city.

PROFESSOR JOHN HUTTON BALFOUR, Emeritus Professor of Botany in the University of Edinburgh, died February 11th, in the seventy-seventh year of his age. He was chosen to fill the place of Sir William Hooker, at Glasgow, when Hooker was called from that place to Kew, and was elected to the Regius Professorship of Botany at Edinburgh in 1845. He retired from this position, on account of infirmity, in 1877. He published much, but was better known as a teacher than as an original investigator.

MR. F. COPE WHITEHOUSE presented to the Academy of Sciences (March 24th) the results of his geological researches and survey of the cañon of the Nile, with especial reference to the Pyramids of Gizeh. He denies that the material was brought from any considerable distance. Geology and tradition show that the two large piles are reconstructed hills. The whole hill has probably been rebuilt, except the lower 180 feet. It seems to have been done by the excavation of a chamber in the center of the mass of soft, horizontal limestone, and the transfer of blocks from the ceiling to the floor until the top of the hill had been reached. Thus a precarious and dangerous mound of poor, clayey limestone was converted into a permanent protection and stable structure without great expense and without disturbing the beautiful edifices of granite and alabaster tanks and tombs whose remains are still found on the terrace and near the Sphinx at its foot.

THE death, at the age of forty-eight years, is announced of Richard Cortembert, a French geographer, who until 1878 held a position in the geographical department of the Bibliothèque Nationale. Among his works were "Grands Voyages Contemporains" (1864), ("Great Contemporary Voyages"), and "Geographie Commerciale" ("Commercial Geography") for schools (1868.) At the time of his death he was engaged upon a "New History of Voyages."

THE Rev. Dr. J. G. Macvicar, of Moffat, Scotland, who died February 12th, aged eighty-four years, was a diligent student of natural science in early life, and was from 1827 the first lecturer in natural history in the University of St. Andrews. He was editor of the "Quarterly Journal of Agriculture," and was the author of "The Elements of the Economy of Nature" and other scientific books and papers, and of a treatise on "The Philosophy of the Beautiful." His best-known work was "An

Inquiry into Human Nature," which was composed during his residence in Ceylon, from 1840 to 1842.

It has been remarked that the destructive force of a tropical hurricane appears to be greater than the velocity of the wind will account for, when compared with the velocity of an ordinary head gale. Mr. Joseph John Murphy suggests, in the London "Spectator," that the fact may be satisfactorily explained by the law that the pressure, and consequently the destructive force of any current, whether of air or water, is proportional, not to the velocity, but to the square of the velocity; so that, if the velocity is doubled, the destructive force is increased fourfold.

J. F. Julius Schmidt, Director of the Observatory at Athens, Greece, died in that city late in February, aged fifty-eight years. He was a German by birth, and was connected with several observatories in Germany before he was called to Athens in 1858. One of his most important works is his map of the moon, which embodies the results of thirty-five years of work. He investigated the volcanic phenomena at Santorin, and composed a work on volcanoes. He studied earthquakes and the relations of the moon to them, and, in meteorology, he published a study on the duration of the twilight.

Hann, of Vienna, objects to the theory that the eruption of Krakatoa filled the air with dust enough to cause red lights all over the world, on account of the quantity of dust it would take. He calculates that the volume of Krakatoa, supposing it to be 822 metres high and four kilometres in diameter at the base, was 13,780 cubic kilometres. Supposing it all to be reduced to dust and scattered over the earth, it would form a thickness of only three hundredths of a millimetre. At a height of ten miles above the surface, the dust-stratum would be still thinner. Herr Hann does not seem to have taken into consideration the fact that the dust came from the bowels of the earth and not from the volcano alone; and he may not have made sufficient allowance for the extremely attenuated condition in which it was.

An International Forestry Exposition is to be opened this year in Edinburgh. It will be devoted to the exhibition of the forest-products of the whole earth, and will be open to all nations.

Professor Heinrich Carl Berghaus, a distinguished German geographer, cartographer, and historiographer, died in Stettin, February 17th, in his eighty-seventh year. Besides his work on general atlases and many special maps, he was the author of the best map of the Iberian Peninsula, of an atlas of Asia with fifteen maps and text, a physical atlas of ninety-three maps; of numerous important works on geography; of many communications to the German scientific papers and departments; and of a text-book of geography, which, translated into the vernacular languages, is in use in schools in India.

The death of Dr. J. Todhunter, an eminent mathematician and author of text-books, is announced.

Captain Neils Hoffmeyer, Director of the Meteorological Institute of Copenhagen since 1872, has recently died. He was the author of an important paper on the storms of the Northern Atlantic; published for three years a daily synoptical weather-chart; prompted the establishment of meteorological stations in Greenland and Iceland, and was Secretary of the International Polar Commission.

M. Jean Baptiste Dumas, the distinguished French chemist, died April 11th, in the eighty-fourth year of his age. Since 1823 he has been constantly adding to our knowledge of organic chemistry. His theory of substitution and his treatise on chemistry as applied to the arts were important contributions to the science. He has been at different times a member of the National Assembly, Minister of Agriculture and Commerce, and Vice-President of the Senate, of France. In 1868 he became Permanent Secretary of the French Academy of Sciences. A portrait and biographical sketch of M. Dumas were given in vol. xviii, p. 257, of "The Popular Science Monthly" (December, 1880).

Drs. Ferrier and Gerald Yeo communicated a paper to a recent meeting of the Royal Society on the effects of lesions of different regions of the cerebral hemispheres. They described experiments conducted upon monkeys, in which they removed, under anæsthetics, certain limited areas of the cortex; the results of the experiments went to confirm in a very exact manner most of the conclusions previously arrived at by Dr. Ferrier and by neuropathologists. The localization of the centers of sight and hearing and the effect of removing portions of the brain in producing anæsthesia on the opposite side of the body were thus tested.

Dr. Wilson, of England, has tried to count the number of hairs on the human head. Taking a fairly hirsute head, he found the number of hairs on a square inch of surface to be 1,066. This, he estimated, would give 127,920 for the whole head. More thickly-clad heads might have 150,000 hairs.

A CORRESPONDENT of "Nature" reports an illustration of the power of organization in the mouse. He was waked up one night by a distinct, continuous grinding under the floor of his room, which lasted till after daylight, when it suddenly ceased, and the room seemed in an instant filled with mice. One of the mice caught on a bell-pull, and climbed upon it to near the ceiling. Then he "turned himself round, and for a few minutes quietly surveyed the room; then deliberately descended, and in two or three minutes not a mouse was left in the room." The correspondent supposes that this scout-mouse was the chief-engineer of the company, and had directed the siege-operations; that he rose to an eminent point to survey the conquest, and that, finding it contained nothing of interest to mice, gave the word to his followers, after which they all retired.

ACCORDING to an essay by Dr. D. J. Macgowan, China has no copyright law, but authors' rights are protected with certainty, upon the theory that their writings are as really property as their material goods, and are so obviously so that no particular designation is required. These rights are hereditary, and not limited. Authors do not make arrangements with publishers; that would be undignified. They have their books cut and printed on their own premises, and then sell them to the trade. Ephemeral books are, however, sold to publishers, and are then liable to be pirated. The book-trade has only the most limited facilities for advertising and circulating its issues; yet, the knowledge of new publications is very quickly spread through the country, and the books get to all interested in them in a remarkably short time.

M. JOSEPH LECORNU has suggested several ways in which balloons might be used in astronomical research. The appearance of heavenly bodies near the horizon is distorted by refraction. We can not make exact allowances for the distortion, because we have no rule by which to measure the rate of atmospheric refraction, and learn the laws under which it varies. With balloons we might sound the air in all weathers, and in time get a rule. Balloons also could take us above the clouds and atmospheric hazes, and enable us to get direct views of eclipses, transits, comets, and meteoric showers when they might be obscured at the surface, and of such phenomena as the aurora borealis and the zodiacal light that are always observed at the surface under difficulties. M. de Fonvielle has already made satisfactory observations and measurements of a comet and observations of shooting-stars, from a balloon.

AN Italian ship has been sheathed with glass instead of copper. The plates are cast like iron plates to fit the hull of the vessel, and are made water-tight by means of a silicate mastic. They are claimed to be exempt from the vices of oxidation and incrustation.

M. WROBLESKY has succeeded in liquefying oxygen in considerable quantities, and then, by removing the pressure, allowing it to boil. By this means he has produced a cold of —186°C., or —302·8° Fahr., at which nitrogen has become solidified into a snow composed of crystals "of a remarkable dimension." M. Wroblesky announces that he has obtained the liquefaction of hydrogen, by exposing it to the cooling influence of liquid oxygen at the instant of evaporation.

A CONFLICT of opinion having broken out between the Municipal Council of Paris and the gas company, as to what the price of gas should be, a scientific commission has been appointed to decide whether the gas industry has so advanced as to justify a diminution in the price.

M. F. TERBY states, in the "Bulletin" of the Belgian Academy of Sciences, that he believes he has found a monthly period for the aurora borealis, corresponding with the returning presentation, every twenty-seven days, of the same sun-spots to the earth.

M. CORNU lately described to the French Academy of Sciences a white rainbow which he saw on the morning of the 28th of November. There had been a heavy hoar-frost, followed by a thick, low fog. This rainbow was wholly white, without even as much iridization as is noticeable in halos, and had a fleecy appearance like that of the fumes of phosphureted hydrogen, or the smoke from the mouth of a cannon.

THE detonations of the recent earthquake in the Straits of Sunda were distinctly heard through all the Philippine Islands—so distinctly that some persons thought a battle was going on, or that some vessel was firing signals of distress.

THE savages of the Maclay coast of New Guinea, according to Dr. Miclucho-Maclay, seldom bury their dead. As soon as a man dies, his body is placed in a sitting posture and covered with palm-leaves. It is then exposed to the fire for two or three weeks, till it becomes wasted away or dried up. The bodies of children are simply hung up to decay in a basket under the roof. Burial is rarely given, except when an old man has survived all his wives and children, and it is then accompanied by numerous ceremonies.

AVERROE, Filosofo Arabo Aristotelico, discepolo d'Avicenna, autore di molti Trattati di Filosofia, e di Medicina.
Fiorì nel Secolo Undicesimo di Cristo Cristo di Raffaello nel Vaticano P. Filippo Stellino

AVERROËS.